APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

REVS. 1458-1788 VOL. 6, NO. 5 MAY 1953

Published Monthly by
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
at Easton, Pa., and edited by
Midwest Research Institute with the co-operation of Linda Hall Library

APPLIED MECHANICS Reviews

Editorial Office: APPLIED MECHANICS REVIEWS, Midwest Research Institute, 4049 Pennsylvania, Kansas City 2, Mo., U.S.A.
Subscription and Production Office: The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., U.S.A.

APPLIED MECHANICS REVIEWS, May 1953, Vol. 6, No. 5. Published monthly by The American Society of Mechanical Engineers at 20th and Northampton Streets, Easton, Pa. The editorial office is located at the Midwest Research Institute, Kansas City 2, Mo., U.S.A. Headquarters of ASME, 29 West 39th St., New York 18, N. Y., U.S.A. Cable address "Dynamic" New York. Price $1.50 per copy, $12.50 a year; to members of ASME and co-operating societies $0.75 per copy, $9 a year. Extra postage to countries outside the Pan American Union, $1.50; to Canada, $0.75. Changes of address must be received at Society headquarters four weeks before they are to be effective on the mailing list. Please send old address as well as new address. By-Laws: The Society shall not be responsible for statements or opinions advanced in papers or printed in its publication (B13, Par. 4). Entered as second class matter, January 11, 1948, at the Post Office at Easton, Pa., under the Act of March 3, 1897.

APPLIED MECHANICS REVIEWS

VOL. 6, NO. 5 MARTIN GOLAND *Editor* MAY 1953

THE PRESENT STATE OF THE THEORY OF THE SHIP

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THE ship is a vehicle whose weight is supported by hydrostatic or hydrodynamic forces. This definition enables us to distinguish the ship from land and air vehicles, although some kinds of amphibian craft already exist which cannot be classified in a rigorous manner.

The investigation of those properties of the ship which are fundamental from the point of view of rational mechanics is the subject of the "theory of the ship" or "ship theory." This designation, though not yet universally accepted, is more to the point than "theoretical naval architecture"; it agrees with the international nomenclature derived from the French "théorie du navire."

By listing the basic mechanical properties with which the ship has to comply, we immediately obtain the commonly accepted subdivisions of our subject: (1) Lift; (2) stability; (3) ability to progress (resistance and propulsion); (4) seaworthiness (behavior in a seaway); (5) maneuverability; (6) strength; and (7) lack of vibrations. The scientific tools needed are furnished by statics and dynamics, hydrodynamics, and the theory of strength and elasticity. Frequently, problems of strength are treated separately as an independent branch, and the designation "ship theory" is restricted to the investigation of the equilibrium and motions of a ship as a rigid body. Such a convention will be accepted here; it is not objectionable, provided it is kept in mind that frequent overlapping of both branches occur.

The state of knowledge shortly before World War II has been summarized at an elementary level in "Principles of naval architecture." However, an adequate branch of hydrodynamics which treats effects due to the presence of the free surface has not been adequately dealt with there. In analogy with aerodynamics, one could call this branch "ship hydrodynamics." In dealing with our problems, the concepts of sources and sinks and doublets are fundamental. From a methodological point of view, recent studies of the free-surface effects represent the most important contribution to ship theory.

We consider briefly the progress in the main fields listed earlier.

1 LIFT

Besides the class of displacement (Archimedean) vessels which includes normal ships and submerged bodies like submarines, torpedoes, etc., we must consider the class of "hydrodynamic" craft which consists of gliding and hydrofoil boats. The computation of buoyancy of Archimedean vessels is a well-established routine procedure. The principles of dynamic lift of gliding vessels have been established earlier, but not too much detailed work has been done. Especially, no investigations have been made on the actual pressure distribution over the hulls of an intermediate kind of high-speed craft such as round-bottomed and V-shaped motorboats, i.e., vessels operating in the transition between floating and gliding.

The lift of hydrofoils with a horizontal straight axis and infinite span has been computed, but the lift of more complicated hydrofoil configurations must be determined experimentally.

2 STABILITY

In naval architecture, the expression "stability" is used for diverse concepts. First, it is used in the proper sense for the equilibrium of a state. Secondly, by stability moment for finite (large) angles of heel and trim, one denotes the magnitude of the couples due to the buoyant and gravity forces. We propose that the misleading "stability" designation in the latter case be dropped, and that the couples mentioned be denoted as "righting couples" of roll φ ("Reed's diagram") and trim ψ. By applying the simplest laws of mechanics, one can establish that the *stability* in a heeled condition depends, for example, upon the law governing the shift of the weight causing the heel, or, more generally, upon the character of the external moment as a function of the heel.

Astonishingly, in computing Reed's diagram, blunders are still occasionally committed because of insufficient accuracy of the methods used. This is one reason why reliable systematic investigations on the dependence of Reed's diagram upon the form of the ship are rather scarce.

Still less has been done about the stability of planing craft and intermediate craft; serious investigations, however, have been devoted to the stability of hydrofoil systems. A basic problem like the stability of vessels in a seaway has not been properly investigated at all.

3 RESISTANCE AND PROPULSION

The modern trend toward increased ship speed makes the problems treated under this heading extremely important. Their solution still requires a vast amount of experimental work, but the impact of theoretical methods is noteworthy.

The determination of ship resistance is in a stage of slight confusion due to the fact that W. Froude's almost universally adopted experimental technique no longer corresponds to our present

scientific concepts. For the purpose of systematization, we differentiate the following kinds of ship resistance: (a) Frictional; (b) viscous pressure; (c) wave; (d) spray resistance. The last component is negligible for normal displacement vessels. Instead of separating the total resistance, following Froude, into the frictional resistance of an "equivalent flat plate" and the residual resistance, it may be advantageous to borrow the concept "viscous drag" from aerodynamics as the sum of (a) and (b). It has been shown that the latter can be determined by a wake survey, even if free-surface effects are present.

The determination of the tangential resistance of flat plates from pipe experiments leads to an overestimation of the former. The shape of the standard friction curve proposed by Schoenherr must undergo minor changes. Resistance curves derived from experiments with pipes roughened by sand do not picture the proper ship conditions. It seems advantageous to distinguish structural roughness (seams, butts, openings in the hull) from the surface roughness due to paint, fouling, etc.

The reduction of tangential resistance in ships is perhaps the most urgent problem. Important progress has resulted from the introduction of welding instead of riveting. For the purpose of power prediction, model testing suffers slightly in importance as compared with full-scale experiments (trials). A crisis in model research dealing with slow, full ship forms arose because of the neglect of actual flow conditions (laminar flow). This difficulty is being corrected. The foundations of model-testing techniques by application of hydrodynamics theory is progressing well.

Methods have been developed in aerodynamics for calculating the total viscous drag; these methods are applicable to plane and axially symmetric flow. The determination of the viscous pressure resistance of ships requires further experimental evidence. Especially, investigations are needed to establish conditions which lead to the beginning of separation.

Much analytical work is being done at present in the field of wave resistance of normal vessels. Attempts are being made to use the wave-resistance theory as a starting point for a systematic survey of resistance properties of hull forms.

The state of knowledge for very fast displacement ships, where we have to rely wholly on experimental methods, is rather unsatisfactory. The same applies to some extent to gliding vessels, although here fundamental relations were established some 20 years ago.

Hydrodynamics theory has contributed to the understanding of shallow-water effects. Remarkable success has been reached in calculating the wave resistance of wholly submerged bodies moving close to the surface.

As for the resistance of hydrofoils, reference is made to the remarks on lift.

Much experimental and theoretical work has been done on propellers. The simple vortex-line theory failed to give satisfactory results for propellers with broad blades. Efforts are being made at present to introduce an appropriate correction for the flow curvature. The theory has been extended to medium and heavily loaded propellers. The theory and the actual application of shrouded propellers have progressed. Water-jet propulsion is only in the theoretical stage at present. Model experiments on paddle wheels have proved that this device is not yet completely outmoded.

4 SEAWORTHINESS

The study of ship motions in a seaway yields important contributions to the solution of the intricate problem of seaworthiness. The linear theory developed by Krylov, mainly with respect to exciting forces, has been supplemented by studies of damping forces and added masses.

So far, a better understanding of the damping phenomena has resulted, especially of the influence of the shape of the sections on the damping. The overwhelming importance of wave damping in heaving and pitching has been well established. There are indications that with increased speed the importance of wave damping decreases. This could be a serious handicap, but, fortunately, the loss seems to be compensated by viscous effects, at least within the range of moderate Froude numbers.

It is realized that the linear approach can only furnish a general description of seaworthiness phenomena. Some successful attempts have been made to use nonlinear mechanics.

The actual boundary conditions on the hull, which were neglected in Krylov's memoir, are being satisfied at present in a rather crude manner, but one remarkable study treats the phenomena as a boundary problem, though under very restricted assumptions.

Progress is being made in the field of activated roll stabilization; some tentative studies deal with the possibility of pitching stabilization. Fins are more popular at present than tanks.

Some progress has been reached in dealing with the resistance in waves. The trend toward higher ship speeds emphasizes the importance of studies in this field. Besides the resistance, the necessity of avoiding impacts (hydrodynamic shocks) limits the possibility of maintaining speed in a seaway. The investigation of these impacts, which follows lines developed in the theory of seaplanes, is a fascinating and urgent problem.

5 MANEUVERABILITY

Earlier activity in this field centered around the hydrodynamic properties of rudders. The theory of low-aspect-ratio wings still has many gaps. Essential difficulties are met when dealing with the propeller race. The more recent application of concepts and methods, borrowed from aerodynamics, to directional stability and steering problems in naval architecture led to a better understanding of these formerly neglected problems. Results found earlier for airships have been applied to wholly submerged bodies. The maneuverability of ships in a seaway presents rather difficult problems.

6 ELASTIC VIBRATIONS

The study of hull vibrations requires the simultaneous application of the theories of elasticity and hydrodynamics. The calculation of higher-order frequencies of the hull presents serious difficulties primarily because of the dependency of the moment of inertia of the cross sections of the hull on the period of the oscillations, due to variability of the effective width of the plating. More satisfactory from a practical point of view are the attempts *to avoid* elastic vibrations by eliminating periodical exciting forces; for example, by increasing the number of propeller blades, removing the tips from the hull, etc.

Shipbuilding is an old trade, but ship theory has not yet reached the same high level as aerodynamics and airplane mechanics. To some extent this is due to intrinsic difficulties involved, but still more it is due to a lack of scientific spirit. Attempts are being made, however, to improve the present rather unsatisfactory situation. These attempts are more successful than earlier approaches because of recent developments in hydrodynamics.

Ship theory is an applied science. Its purpose consists in creating a rational foundation for the design and the development of ships. Contrary to the obsolete viewpoint of protagonists of a purely empirical approach, many problems in naval architecture need scientific elucidation, just as do the analogous problems in the airplane industry. Too much in our field still depends upon opinion rather than knowledge. It can be stated that the ship

will be able to keep its own in the contest with the airplane only if full use is made of scientific knowledge and techniques.

REFERENCES

Because of the vastness of the subject, it is impossible to give credit even to the most important original works. Therefore, reference is made to:

1 The transactions of various institutions and societies, e.g.:

Trans. Instn. nav. Arch. Lond.
Trans. Soc. nav. Arch. mar. Engrs. N.Y.
Bull. Assn. tech. marit. aéro. Paris
Jahrbücher der Schiffbautechnischen Gesellschaft, Hamburg

2 The reports published by Research Institutes, e.g.:

David Taylor Model Basin, Washington, D.C.
Experimental Towing Tank, Stevens Institute, Hoboken, N.J.
(These sources generally furnish ample bibliographical data.)

3 Applied Mechanics Reviews.

Communications

Concerning **AMR 6, Rev. 354 (February 1953):**
Author's name should read Melyakhovetskiĭ, A. S. Ed.

Concerning **feature article, AMR 6 (Jan. 1953): R. M. Davies, Stress waves in solids.**

Since I wrote the review article on this subject, I have found that I omitted an important recent text and review article from the list of references:

Sneddon, I. N., Fourier transforms, AMR **4**, Rev. 3753.

Schoch, A., Schallreflexion, Schallbrechung und Schallbeugung, AMR 5, Rev. 3572. R. M. Davies, Wales

Theoretical and Experimental Methods

(See also Revs. 1479, 1501, 1509, 1510, 1519, 1537, 1568, 1594, 1688, 1729, 1730, 1771)

1458. **Salzer, H. E., On calculating the zeros of polynomials by the method of Lucas,** *J. Res. nat. Bur. Stands.* **49**, 2, 133–134, Aug. 1952.

The coefficients of the polynomial $f(x)$ of the degree n are assumed to be given exactly (integral or rational). Then, with the values $f(x_i) = 0$, at $n + 1$ points x_i, the essential part of Lagrange's formula of interpolation, $h(x) = \Sigma A_i/(x - x_i)$, is formed, which has the same zeros as $f(x)$. By computing $h(x)$ at several points in the neighborhood of the zero and inverse interpolation, the root—real or complex—is determined, according to the author, with remarkably little computation labor. An example is given. F. A. Willers, Germany

✎1459. **Huntley, H. E., Dimensional analysis,** London, Macdonald & Co., Ltd., 1952, ix + 158 pp. 20s.

Book was written for use in instruction of undergraduate physics students. Accordingly, emphasis is on "how-to-solve" problems by use of dimensional analysis. Correspondingly, text is somewhat weak on general theory (thus, the central theorem of dimensional analysis, Buckingham's theorem, is not even mentioned *per se*), but quite strong in interesting illustrative examples drawn from numerous physical domains. A unique feature of text is specific illustration, through solution of numerous examples, of the more sharply formulated solutions that can sometimes be obtained by consideration of length as a vector quantity, thence using directed lengths L_x, L_y, and L_z as fundamental quantities instead of simply length L alone; and similarly considering M_μ and M_i instead of M alone, where M_μ and M_i stem from consideration of mass in connection, respectively, with quantity of matter and with inertia. Though general theory is less explicitly treated than in Langhaar's recent book [AMR **4**, Rev. 4042], reviewer is of opinion that any reader of the latter can read Huntley's book with profit. T. J. Higgins, USA

1460. **Braun, I., Physical components of a tensor,** *Bull. Res. Counc. Israel* **1**, 1/2, p. 127, Mar. 1951.

✎1461. **Lotze, A., Vector and affinor analysis [Vektor- und Affinor-Analysis]** (in German), München, Verlag R. Oldenbourg, 1950, 276 pp.

A useful expository work. The chapter titles are: (I) Vector and affinor algebra; (II) Vector and affinor analysis; (III) Application to differential geometry; (IV) Application to mechanics (including deformable bodies); (V) Application to the electromagnetic field. There is an appendix on 4-space vectors with application to electrodynamics of the restricted theory of relativity. L. M. Milne-Thomson, England

✎1462. **Nielsen, J., Textbook in rational mechanics. III. Vector analysis, potential theory, continuous media, flows, complex potential [Laerebog i rationel mekanik. III. Vektoranalyse, potentialteori, kontinuerlige medier, strømninger, komplekst potential]** (in Danish), Copenhagen, Jul Gjellerups Forlag, 1952, viii + 197 pp.

The first two volumes of this text were subtitled "Statik" [1933, 1943] and "Dynamik" [1934, 1945]. This volume, stemming from lectures given at the Danish Technical University and the University of Copenhagen, is designed to provide the necessary mathematical background for a study of the mechanics of continua, as well as an introduction to some of its fundamental concepts and theorems. Thus, there is no discussion of problems associated with special geometrical configurations with the exception of a treatment of the Joukowsky airfoil at the end of the last chapter, and an occasional example. The standards for both rigor and clarity are high, and this text should make a valuable companion to standard treatises on the mechanics of continua. Only linear elasticity and viscosity laws are considered. The subtitle above gives the titles to the five chapters, and there is also an appendix on dyads. J. V. Wehausen, USA

1463. **Sullivan, R. D., A comparison of two methods of linearized characteristics for a simple unsteady flow,** *NACA TN* 2794, 28 pp., Sept. 1952.

Two variations of the method of small perturbations (applicable to the solution of nonlinear hyperbolic partial differential equations) are compared by using each to determine the one-dimensional, nonsteady gas flow produced by the rotation of a thin tube of gas about an axis normal to the tube axis. Both methods involve linearization and the use of the characteristic equation. They differ in that, in the first method, the linearization is applied to the differential equation expressed in terms of its original variables, while in the second method it is applied to the characteristic system.

The principal advantage of the second method appears to be that the characteristics of the differential equation are derived during the solution, whereas in the first method, only the characteristics of the unperturbed equation appear.

The reviewer would like to have seen in this paper a further

comparison of the two methods, using an example requiring numerical solution, in order to compare the labor required and the accuracy produced for given characteristic net mesh size.

J. Lorell, USA

1464. Clemmow, P. C., and Munford, Cara M., A table of $(1/2\pi)^{1/2}e^{1/2i\pi\rho^2}\int_{\rho}^{\infty} e^{-1/2i\pi\lambda^2}\,d\lambda$ for complex values of ρ, *Phil. Trans. roy. Soc. Lond.* (*A*) **245,** 895, 189–211, Sept. 1952.

In the theory of wave propagation, the above function has applications for which ρ may be complex within a certain range of argument. Tables of the real and imaginary parts of the function are given to four decimal places, for values of $|\rho|$ from 0 to 0.80 at intervals of 0.01, and for values of arg ρ from 0° to 45° at intervals of 1°. From authors' summary

1465. Anonymous, Tables of the Bessel functions $Y_0(x)$, $Y_1(x)$, $K_0(x)$, $K_1(x)$, $0 \leq x \leq 1$, *U. S. Dept. Comm., Nat. Bur. Stands. appl. Math. Ser.* 25, 60 pp., Sept. 1952.

This is a reprint of Applied Mathematics Series 1. Errata noted in original printing have been corrected. Values of functions in title are given to 7 and 8 significant figures. The mesh is 0.0001 for small x only; otherwise it is 0.001. Auxiliary functions to facilitate interpolation near the origin are also recorded. Y. Luke, USA

1466. Malkin, I. G., On the characteristic values of linear differential equations (in Russian), *Prikl. Mat. Mekh.* **16,** 1, 3–14, 1952.

Let the characteristic numbers (= c.n.) λ_i in the sense of Lyapunov [see *Annals of Math. Studies* no. 17, pp. 225–243] of the system

$$\dot{x}_s = \Sigma p_{sj}x_j;\ s, j = 1, 2, \ldots, n \qquad [1]$$

be known. It is proposed to compare with them those λ_i' of

$$x_s = \Sigma(p_{sj} + \varphi_{sj})x_j \qquad [2]$$

Here p_{sj}, φ_{sj} are continuous and bounded on $[0, \infty]$ and $\lambda_1 \geq \lambda_2 \geq \ldots \lambda_n$, $\lambda_1' \geq \lambda_2' \geq \ldots \lambda_n'$. The set $\{\lambda_i\}$ is *stable* whenever given ϵ arbitrarily small there is an $\eta(\epsilon)$ such that if the $|\varphi_{sj}| \leq \eta$ then the $|\lambda_i - \lambda_i'| < \epsilon$. The set of n linearly independent solutions x_{sj} is *normal* whenever it has as many c.n.'s λ_i as possible and λ_n, then $\lambda_{n-1}, \ldots$, are in turn repeated as often as possible [Lyapunov, loc. cit. p. 233]. The system [1] is regular [ibid. p. 237] whenever the sum of the c.n.'s in a set of normal solutions is $-\mu$ where μ is the c.n. of exp $(-\int p_{ss}dt)$.

Let $x_{sj}(t, t_0)$ denote the system of solutions of [1] such that $\bar{x}_{sj}(t_0, t_0) = S_{sj}$ and let μ_j be the c.n. of the solution $\bar{x}_{sj}$. It is supposed that [1] is such that whatever $\gamma > 0$:

$$\begin{aligned} |\bar{x}_{sj}| &< C(\gamma)e^{(-\mu_j+\gamma)(t-t_0)} \text{ for } t \geq t_0 \geq 0 \\ |\bar{x}_{sj}| &< C(\gamma)e^{(-\mu_j-\gamma)(t-t_0)} \text{ for } t_0 \geq t \geq 0 \end{aligned} \qquad [3]$$

Theorem 1. If [3] holds, then given ϵ there is an η such that if the $|\varphi_{sj}| \leq \eta$ then the $\lambda_i' \geqq \lambda_i - \epsilon$. *Theorem 2.* Under the same conditions, if [1] is regular then the set $\{\lambda_s\}$ is stable.

Suppose now that

$$|\bar{x}_{sj}| < M \exp(-\alpha(t - t_0)),\ M > 1,\ \alpha > 0 \qquad [4]$$

where α is independent of t_0. Let m denote the largest number of terms in any expression $\sum_j \bar{x}_{s\beta}(\varphi_{\beta_1 x_1} + \ldots + \varphi_{\beta_n x_n})$. *Theorem 3.* If [4] holds, then the i' will all be positive if the φ_{sj} satisfy $|\varphi_{sj}(t)| < \alpha/mM$.

Additional references: Bílov, B. F., *Prikl. Mat. Mekh.* **14,** 1950; Persidskiĭ, K. P., *Izv. Akad. Nauk Kazakh. SSR* no. 1, 1947; Chetaev, I. G., Ustoĭchivost' dvizheniya, Gostekhisdat, 1946; Shtokalo, I. Z., *Mat. Sbornik*, 19, no. 2, 1946.

S. Lefschetz, USA

1467. Minasyan, R. C., On a mixed boundary problem for the Laplace equation for a rectangle (in Russian), *Prikl. Mat. Mekh.* **16,** 3, 293–304, May/June 1952.

In heat transfer, theory of elasticity, hydrodynamics, etc., problems are often encountered in which the unknown function is determined by giving its values $U = L(s)$ on a part C_1 of the contour C of a given region (s belongs to C_1), and a combination of the values of the function with its normal derivative $\partial U/\partial n + hU = M(s)$ on another part C_2 of the same contour (s belongs to C_2). The paper solves the mixed boundary problem for the Laplace equation for a rectangle, assuming axial symmetry.

From author's summary

1468. Solntsev, Yu. K., On stability according to Lyapunov of the equilibrium positions of a system of two differential equations in the case of discontinuous right-hand sides (in Russian), *Moskov. Gos. Univ. Uchenîye Zap.* **148,** 4, 144–180, 1951.

Let G be a planar region subdivided by a finite graph Γ (which includes the boundary of G and whose arcs are differentiable) into subregions $G_1, \ldots, G_N$. Let there be given a system

$$\dot{x} = X(x, y),\ \dot{y} = Y(x, y) \qquad [1]$$

where X, Y in each G_ν are continuous and in each compact subset of G_ν satisfy a Lipschitz condition. A boundary point q of one of the G_ν may belong to one of four types. Denote by V the vector (X, Y) and by γ a path. Then: (a) for some ν, $V(p) \to 0$ as $p \to q$ on G; (b) no γ on any G_ν leaves G_ν at q; (c) no γ on any G_ν enters G_ν at q; (d) the two circumstances excluded under (b) and (c) both arise at q. Under (*b*), one agrees that γ for all t after t_0 when it reaches P, coincides with q, and under (c) the same but for all t before t_0 when it reaches q. A boundary point q is *quasistationary* (= q.s.) whenever all the boundary points nearer to q than some ϵ are of type (a), (b), or else points common to the boundaries of just two regions G_μ, G_ν with both vectors $V(q)$ not tangent to the boundary arc through q.

The author discusses more especially the stability of the q.s. points. In this connection, a basic role is played by the *reduced* systems. The graph Γ for such a system consists of a finite number of rays issued from the origin O, and the G_ν are the consecutive sectors determined by the rays. In G_ν [1] has the form

$$\dot{x} = a_{1\nu}x + b_{1\nu}y,\ \dot{y} = a_{2\nu}x + b_{2\nu}y \qquad [2]$$

with constant coefficients and nonzero determinant of the coefficients. Moreover, the boundaries are regular in the sense that along the sector boundary, say of G, the vector V is never tangent to the boundary. There are two types of sectors: (a) Sectors with rotation, i.e., such that the paths entering from one side leave from the other; (b) sectors with screen, i.e., those for which no path behaves in the preceding manner.

The necessary and sufficient condition for the origin to be stable relative to a reduced system with at least one sector with screen, is that it be stable relative to every sector with screen. The stability is then asymptotic.

A complicated analytical stability criterion is also given when the sectors are all with rotation.

Similar systems are considered save that the boundaries of the sectors are curvilinear and not paths. If they are not tangent, one replaces each sector by the sector of the tangents. The stability of the resulting reduced system governs that of the given system. If some of the boundaries are tangent, one suppresses all but the first of a tangent set and proceeds in the same manner.

Extension is also made to systems [1] with the G_ν still curvi-

linear sectors and X, Y nonlinear with first-degree terms suitably restricted.

The author considers then a general, bounded G, with system [1] linear in each G_ν. Here again the same results are obtained for isolated q.s. points under appropriate restrictions on the individual linear systems. Finally, stability is considered for a set of q.s. points making up a tree T in the graph Γ. The general method consists in attaching a suitable reduced system to each vertex of T. The stability of every one of these reduced systems governs the stability of T [see A. A. Andronov and A. G. Maier, *Avtomatika i Telemekhanika* **8**, 5, 1947; Nemitskiĭ and Stepanov, "Qualitative theory of differential equations" (Russian), Gostekhisdat, 1947; E. A. Barbashin, *Moskov. uchenîye Zap. Univ., Ser. mat.* 2, 1949]. S. Lefschetz, USA

1469. Persidskiĭ, K., On the stability of solutions of denumerable systems of differential equations (in Russian), *Izv. Akad. Nauk Kazakh. SSR* **56**, *Ser. Mat. Mekh.* **2**, 3–35, 1948.

Let there be given a system

$$\dot{x} = \omega(t, x) \qquad [1]$$

where x and ω are vectors with a countable number of components, $t \geqq 0$, and the components x_s of x are bounded: $|x_s| \leqq R$. Moreover, [1] satisfies a Lipschitz-like condition

$$|\omega_s(t, x') - \omega_s(t, x'')| \leqq A(t)\beta_s|x_1' - x_1''| + \ldots + \beta_1|x_s' - x_s''| + \alpha_1|x'_{s+1} - x_{s+1}| + \ldots$$

where $A(t)$ is positive and continuous for $t \geqq 0$ and the α_s, β_s are positive and such that $\beta_1 + \beta_2 + \alpha_2 + \ldots + \beta_m + \alpha_m + \ldots$ is convergent. Furthermore, (a) $\omega(t, 0) = 0$; (b) $|\omega_s(t, x)| < B(t)$, for all bounded x_s, where $B(t)$ is continuous for $t \geqq 0$; (c) for every sequence $u_1(t)$, $u_2(t)$, . . ., of functions continuous on a certain segment $[a, b]$, the functions $\omega_s(t, u(t))$ are measurable. Under the circumstances, the author develops for the system [1] the general theory of Lyapunov (first and second methods).

S. Lefschetz, USA

1470. Gorshin, S., On stability of motion with constantly acting disturbances (in Russian), *Izv. Akad. Nauk Kazakh. SSR* **56**, *Ser. Mat. Mekh.* **2**, 46–73, 1948.

1471. Gorshin, S., Critical cases (in Russian), *Izv. Akad. Nauk Kazakh. SSR* **56**, *Ser. Mat. Mekh.* **2**, 74–101, 1948.

1472. Gorshin, S., On the stability of the solutions of a denumerable system of differential equations with constantly acting disturbances (in Russian), *Izv. Akad. Nauk Kazakh. SSR* **60**, *Ser. Mat. Mekh.* **3**, 32–38, 1949.

Let there be given a system

$$\dot{z}_k = Q_k(z, t) + R_k(z, t), \qquad k = 1, 2, \ldots, n \qquad [1]$$

where for $t \geqq 0$, Q_k, R_k are continuous, positive in a certain real or complex domain H and have a unique Cauchy integral there. Let $z_k = \varphi_k(t)$ be a solution of [1] and $z_k = \psi_k(t)$ a solution of the analogous system with the R_k replaced by zeros. It is assumed that $\psi \in H$ for all $t \geqq 0$. Consider now n functions $F_\nu(z, t)$ continuous and single-valued together with all their partials as to the z_k in H and this for all $t \geqq 0$. It is assumed furthermore that the Jacobian

$$\frac{D(F_1, \ldots, F_n)}{D(z_1, \ldots, z_n)} \neq 0$$

and that the partials $\partial F_\nu/\partial x_s$ are uniformly bounded in H. Let finally $x_s = F(z, t) - F(\psi, t)$, $z = \varphi(t)$. Given ϵ, does there exist σ, ρ such that if $t_0 \geqq 0$ and

$$|\psi_k(t_0) - \varphi_k(t_0)| < \sigma, \quad |R_k(z, t_0)| < \rho$$

then $|x_k| < \epsilon$ for $t \geqq t_0$. If so, the system [1] is said to be stable relative to the functions F for positive perturbations, otherwise it is said to be unstable in the same sense. In the first two papers, author extends more or less to this type of stability the general results of Lyapunov. In the third paper he discusses the extension to countable systems patterned after those of Persidskiĭ (see preceding review). S. Lefschetz, USA

1473. Imai, I., Kaji, K., and Umeda, K., Mapping functions of the NACA airfoils into the unit circle, *J. Fac. Sci. Hokkaido Univ.* (II) **3**, 265–304, 1950.

A method of conformal mapping developed by one of the authors [I. Imai, *J. Soc. aero. Sci. Japan* **9**, 865, 1942; I. Imai and K. Sato, *J. aero. Res. Inst. Tokyo Imp. Univ.* **247**, 91, 1945], is sketched and a numerical procedure based on this method is described. The method depends upon the reduction of the problem of calculating the function which maps a simply connected region conformally on the exterior of a circle to the problem of solving a singular integral equation of the Theodorsen-Garrick type. This method is applied to 32 NACA airfoils to calculate several terms of the series which represents the mapping function, and some empirical results are given relating these coefficients and the parameters of the airfoils. Extensive tables are given.

C. Saltzer, USA

1474. Paynter, H. M., Electrical analogies and electronic computers: surge and water hammer problems, *Proc. Amer. Soc. civ. Engrs.* **78**, Separ. no. 146, 28 pp., Aug. 1952.

By normalizing the variables, i.e., converting them to dimensionless parameters, and by establishing basic analogies between flow variables and electrical parameters, author has demonstrated the feasibility of utilizing high-speed analog computers to determine the behavior of hydraulic systems in which surge phenomena are a major problem. His basic analogy is flow velocity ↔ current and head ↔ voltage, and nonlinear aspects of the problem (friction, e.g.) are included in the solutions. The results, e.g., tank level vs. conduit flow, are displayed as patterns on an oscilloscope screen. Some typical examples of water-hammer resonance and surge-tank operation are included, together with adequate references. P. G. Hubbard, USA

1475. Vilenkin, N. Ya., On some almost orthogonal systems of functions (in Russian), *Prikl. Mat. Mekh.* **16**, 3, 382–384, May/June 1952.

Denoting $2 \sin x \sin [(m + 1)x]$ by $P_m(x)$ and considering the two systems of functions of two variables, $0 \leqq x \leqq \pi$, $0 \leqq y \leqq \pi$: $P_m(x)P_n(y)$ and $Q_{mn}(x, y)$, where $Q_{00} \equiv 1$ and $Q_{m0}(x, y) = P_m''(x)P_n(y) + P_m(x)P_0''(y)$, author proves that the first system is closed, while the second system becomes closed only if it is completed by adjoining to it the functions $p_k(x, y)$, $q_k(x, y)$, $p_k(y, x)$, $q_k(y, x)$, where $k = E(k) \geqq 1$, defined as follows

$$4k \operatorname{ch}(\pi k/2)p_k(x, y) = \operatorname{sh}[k(\tfrac{1}{2}\pi - y)] \cos kx$$
$$4k \operatorname{sh}(\pi k/2)q_k(x, y) = \operatorname{ch}[k(\tfrac{1}{2}\pi - y)] \cos kx$$

[See also AMR **4**, Rev. 4094.]

Courtesy of Mathematical Reviews E. Kogbetliantz, USA

1476. Bobeth, W., Contribution to the problem of thickness measurement of glass fibers (in German), *Faserforsch. Textiltech.* **3**, 1, 19–27, 1952.

The different methods of measuring the diameter of glass fibers are discussed in order to get the "true thickness."

1 The methods of examining the thickness without mount

are shown first. With microscopical examinations, author finds that the opening of the iris diaphragm has a great influence on the measurement of the diameter and, consequently, the breaking length. The values obtained with large openings are smaller than those obtained with more closed openings of the diaphragm. The difference is more sensible for 5 and 10μ fibers than for 30μ fibers. The comparison of the optical results with the mechanical results are in the best agreement when the former are made with large openings and moderate magnification.

2 The results of optical methods using a mounting agent are described next. Although the influence of the opening is small, a tendency similar to that shown in the method without mounting agent was found. The best agreement between results of measurement in the air and with glycerin was obtained when the open diaphragm was used in the two cases.

D. De Meulemeester, Belgium

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1470, 1471, 1472, 1497, 1501, 1504, 1531, 1758)

1477. Buckens, F., On a similitude property of average configurations of moving indeformable bodies (in French), *Ann. Soc. Sci. Bruxelles* (1) **66**, 61–69, 1952.

As a plane moves over a fixed plane, each point in the moving plane describes a curve in the fixed plane. If $p(t)$, an arbitrary function of the time t, is used as a weighting function, then each curve can be replaced by a point which is the weighted mean position of the moving point. By the use of the complex variable, it is shown that the configuration made by a set of weighted means corresponding to a selected set of points is similar to the configuration of the selected set of points. In particular, if $p(t) = 1/t$, then the configurations have the same size. If the projections of the motions are expanded as a Fourier series, the Fourier coefficients correspond to the mean positions. A motion may then be represented as the sum of rotating vectors in which the rates of rotation are proportional to the orders of the coefficients [cf. Biezeno and Grammel, "Technische Dynamik," Berlin, Springer, 1939, p. 847]. The method is applied to the motions of a slider and crank mechanism (a crosshead mechanism). The uses of various weighting functions are discussed.

M. Goldberg, USA

1478. Dobronravov, V. V., On certain relations in the problem of motion of a rigid body about a fixed point in Euler's case (in Russian), *Moskov. Gos. Univ. Uchenîye Zap.* **154**, *Mekhanika* 4, 55–59, 1951.

The author of this unusual paper proposes to prove some "yet unnoticed" relations in the title problem. The first one (8) is equivalent to the theorem that the fixed angular-momentum vector moves, relative to the body, on the "invariable cone" [Routh, "Advanced rigid dynamics," part II, p. 104], but the author's proof is more indirect than the classical one. The second relation (17) is obtained by renaming the fixed axes (one of them is directed along the angular momentum), using an even more indirect proof of the theorem mentioned, and substituting, for the directional cosines, the expressions in terms of Eulerian angles. Thus, a more impressive form of the first relation is obtained, but it is not yet clear to the reviewer why (17) is not divided through by the factor $\sin\theta$ common to all its terms. No comment is made about the equivalence of (8) and (17). The third relation (19a) is very involved and links the Eulerian angles with their first derivatives. Since it contains no integration constants, the author concludes that (19a) is a "nonholonomic constraint." (Reviewer observes that author's choice of one of the fixed axes reduces to zero two of the "reference" constants depending on the choice of the fixed frame. Thus (19a) is an involved form of one of the two independent "constant-free" first integrals which exist in the Euler case without being very helpful.)

A. W. Wundheiler, USA

1479. Bader, W., On the influence of parameters on simple unsteady motions (in German), *ZAMM* **32**, 10, 297–305, Oct. 1952.

Euler's angles and the velocity vector are introduced as dependent variables in the linearized equations of motion of a rigid body in a resisting medium. Applying Laplace's transformation, it is shown that expansions in terms of decreasing powers of the independent variables of the transformed region indicate how the motion varies with time. Knowledge of the normal frequencies is not necessary in order to describe the variation of the motion with time after equilibrium has been disturbed.

From author's summary by A. R. Mitchell, Scotland

1480. Hugenholtz, N. M., On tops rising by friction, *Physica* **18**, 8/9, 515–527, Aug./Sept. 1952.

Author investigates the motion and the interesting behavior of the tippe top. The latter is a body which is symmetrical about an axis and which moves with a spherical surface on a horizontal plane. He derives general equations of motion and presents two integrals. The paper deals with the following cases: (a) The frictionless motion where the supporting force on the top has a vertical component only; (b) the motion under influence of a small friction; (c) the motion with friction so great that sliding on the supporting plane is prevented. The behavior of the top seems to be determined essentially by the relative difference of the moments of inertia and by the eccentricity of the mass center. In the appendix, author discusses the unexpected rising of the top on its stem. He treats the phase of the motion from the exact moment the top is still entirely supported on the sphere to the moment the top begins to rest only on its stem.

J. Boehm, USA

1481. Bödewadt, U. T., The symmetrical top subjected to a time-constant torque (in German), *Math. Z.* **55**, 310–320, 1952.

Author solves the differential equations of motion of a symmetrical top subject to forces such that the torques about the principal axes of inertia of the top are constant with respect to time. It is suggested that the modern use of jet propulsion now gives such problems an interest which they have lacked previously.

Courtesy of Mathematical Reviews L. A. MacColl, USA

1482. Nightingale, J., Dynamic reactions in hop dampers for bogie undercarriages, *Aircr. Engng.* **24**, 284, 298–299, 318, Oct. 1952.

Article concerns multi-wheel bogie (tandem) undercarriages on large planes. When brakes are applied to stop spinning of wheels in flight, the angular momentum of the wheels causes the undercarriage to tend to rotate about its suspension axis. This rotation is controlled by a "hop damper." A similar tendency is produced if the brakes are applied while the plane is moving on the ground. Differential equations of motion are developed and solved, subject to simplifying assumptions, for both cases.

W. B. Stiles, USA

1483. Sexl, T., On the motion of a material point in a resistant medium of variable density (in German), *Acta Phys. Austr.* **5**, 148–151, 1951.

Consider the motion of a material point in a resisting medium

whose density decays exponentially with altitude. Assume that the positive z-axis is directed downward and that the resistance to the motion of the point is proportional to the density of the medium and to the nth power of the instantaneous velocity $\dot{z}$ of the moving point. The equation of motion is then $\ddot{z} = g - k \exp(\alpha z)\dot{z}^n$. It is integrated in the closed form for $n = 1$ and $n = 2$ with the initial conditions $z = H$, $\dot{z} = 0$ for $t = 0$.

E. Leimanis, Canada

1484. **Castoldi, L., Permanent vector lines in the motion of a deformable continuum and motions with streamlines "substantially permanent"** (in Italian), *Ist. Lombardo Sci. Lett. R. C. Cl. Sci. Mat. Nat.* (3) **14(83)**, 259–264, 1950.

The author derives Zorawski's criterion for permanent vector lines [*Anz. Akad. Wiss. Krakau* **1900**, 335–342], which he attributes to Lampariello [*Atti Accad. Naz. Lincei Rend. Cl. Sci. Fis. Mat. Nat.* (6) **26**, 383–387, 1937]. He notes some easy consequences; e.g., that the streamlines are material lines if and only if they are steady. [A derivation without use of infinitesimals was given by R. Prim and reviewer, AMR **3**, Rev. 2139.]

C. Truesdell, USA

1485. **Stoppelli, F., An observation on the applicability of the principle of the gyroscopic effect to mutually dependent systems of solids** (in Italian), *Ric. mat.* **1**, 20–26, 1952.

Author discusses certain approximations in the theory of a dynamical system consisting of two solids S_1 and S_2, where S_2 is rotating rapidly about an axis which is fixed in S_2 and passes through the centroid of S_1. It is shown that the legitimate approximations are not necessarily identical with those which would be made if S_2 were a free solid subjected to the actual applied forces and to a force equal to the reaction of S_1.

Courtesy of Mathematical Reviews L. A. MacColl, USA

1486. **Kunin, I. A., Determination of the finite region of initial deviations for which the motions remain asymptotically stable, for a system of two equations of first order** (in Russian), *Prikl. Mat. Mekh.* **16**, 5, 539–546, Sept./Oct. 1952.

Consider the system of equations

$$\dot{x} = p_{11}x + p_{12}y + P'(x, y) = P(x, y) \qquad [1]$$

$$\dot{y} = p_{21}x + p_{22}y + Q'(x, y) = Q(x, y)$$

Assume that (a) the Hurwitz conditions, i.e., $p_{11} + p_{22} < 0$, $p_{11}p_{22} - p_{12}p_{21} > 0$, are satisfied at the origin, and (b) $P'(x, y)$, $Q'(x, y)$ are holomorphic functions in the whole plane whose expansions in power series begin with terms of the second degree in x and y.

Construct a Lyapunov function $V = Ax^2 + 2Bxy + Cy^2$ whose coefficients are determined by the condition

$$\dot{V} = \partial V/\partial x(p_{11}x + p_{12}y) + \partial V/\partial y(p_{21}x + p_{22}y) = -\alpha x^2 - \beta y^2 \qquad [2]$$

with arbitrary positive α and β. According to Lyapunov, the condition [2] determines V uniquely as a positive definite form with coefficients linear in α and β. Consequently, $V = \alpha V_\alpha + \beta V_\beta$, where V_α and V_β are positive definite forms.

Consider for fixed α and β the derivative

$$\dot{V} = \partial V/\partial x P(x, y) + \partial V/\partial y\, Q(x, y) = \dot{V}' + \partial V/\partial x P'(x, y) + \partial V/\partial y\, Q'(x, y)$$

Then the origin is contained in a finite region for which $\dot{V} < 0$. Construct the curve $\dot{V} = 0$, and inscribe the ellipse $V(x, y) = V(x_0, y_0)$, where x_0, y_0 are the coordinates of the point of contact. This ellipse then determines the region of asymptotic stability, i.e., if (x', y') is a point of this region, then

$$x = x(t - t', x', y') \to 0, \qquad y = y(t - t', x', y') \to 0$$

as $t \to \infty$. The dimensions of this region will depend upon the values of the parameters α and β. The construction of the maximum ellipse of stability is considered. E. Leimanis, Canada

1487. **Pismanik, K. M., On the momentary axis of worm gears** (in Russian), *Trudi Sem. teor. Mash. Mekh.* **10**, 39, 5–15, 1951.

A construction is given for the relative instantaneous axis of screw motion of a worm gear meshing with a circular gear, the angle of their axes being arbitrary. The construction is applied to a numerical design problem. A. W. Wundheiler, USA

1488. **Botka, I., Interference of general involute gearing,** *Acta Techn. Hung. Budapest* **3**, 1/2, 99–120, 1952.

Interference analysis of involute gears is based upon profiles corresponding to a 20° pressure angle, including reference to influence of tool displacement. Author's basic assumptions and conclusions are obscured in inept English translation.

L. R. Koenig, USA

1489. **Bevel gears. Tables for the calculation of dimensions of straight bevel gears without profile offset [Kegelräder. Tafeln für die Berechnung der Abmessungen von Geradzahn-Kegelrädern ohne Profilverschiebung],** Braunschweig, Friedr. Vieweg & Sohn; Schriftenreihe Antriebstech. H. 2, 31 pp., 1952. DM 9.60.

A convenient set of tables gives critical dimensions of 20° full-depth bevel gears, in terms of number of teeth as independent variable. They should be useful to gear designers using the metric system. G. A. Nothmann, USA

1490. **Falco, O. A., Gears with small numbers of teeth; correction methods** (in Spanish), *Cienc. y Técn.* **119**, 603, 79–97, Sept. 1952.

This expository paper, starting from first principles, derives the minimum number of teeth to avoid undercutting and minimum correction for small numbers of teeth. These are compared with the standard German method of DIN 870. Author does not appear to be aware of literature in United States, the United Kingdom, France, or Germany more recent than 1932!

E. M'Ewen, England

1491. **Nadile, A., Extension of Liouville's theorem on the integration of canonical systems** (in Italian), *Atti Semin. Mat. Fis. Univ. Modena* **4**, 45–53, 1950.

The theorem that a system of canonical equations of order $2n$ can be completely integrated by quadratures, if n particular independent integrals in involution are given, is given its appropriate generalization to the case when the differential equations are no longer of the usual Hamiltonian type. The equations are those for a holonomic conservative dynamical system in which the momenta are replaced by linear combinations of the momenta as one of the sets of n variables. The coefficients in these linear combinations are arbitrary functions of the coordinates and the time. D. C. Lewis, USA

1492. **Nadile, A., Extension of Liouville's theorem on integration of canonical systems to material nonholonomic systems** (in Italian), *Atti Semin. Mat. Fis. Univ. Modena* **4**, 54–63, 1950.

Author generalizes the work of the paper reviewed above to the

case of nonholonomic equations. In this connection, it is to be remembered that the theorem of Liouville cannot be expected to hold for nonholonomic systems unless certain equalities involving the constraint coefficients are known to hold.

D. C. Lewis, USA

1493. Aymerich, G., Appell transformations in the case of forces linear in velocity (in Italian), *R. C. Semin. Fac. Sci. Univ. Cagliari* **20,** 184–192, 1951.

It is shown that a system of equations of the form

$$d^2x_i/dt^2 = \sum_{j=1}^{n} \varphi_{ij}(x_1, \ldots, x_n)(dx_j/dt) + f_i(x_1, \ldots, x_n), \qquad i = 1, 2, \ldots, n$$

is left invariant by a transformation of the form

$$y_i = y_i(x_1, \ldots, x_n),\ dt = G(x_1, \ldots, x_n)dT$$

provided that certain conditions are satisfied. The theorem is a generalization of a theorem of Appell in which the φ's are all zero [cf. *Amer. J. Math.* **12,** 103–114, 1890]. Some further results of the same type are obtained in case the equations are of Lagrangian form.

D. C. Lewis, USA

1494. Grodzinski, P., Theory of mechanisms. I. Geometrical principles [Getriebelehre. I. Geometrische Grundlagen], 2nd ed., Berlin, Sammlung Göschen Bd. 1061, 1953, 159 pp. DM 2.40.

Most of the material under the subject of this informative booklet is omitted from American textbooks on mechanisms, and the remainder is condensed into a chapter or two. The English terminology is either not standardized or is even lacking. It is hoped that author will make this volume available in English, as he already has for the second volume in "A practical theory of mechanisms" (1947).

The elementary mathematics combines analytical differentiation with graphical methods and vector representation in the study of motions, velocities, and accelerations. The motion of a body over a plane is studied from the paths of the instantaneous center in the fixed plane and in the moving plane. Thus it is readily shown that every motion can be represented as the rolling of one curve over another. All point paths are then seen as roulettes. Curvatures, envelopes, acceleration pole paths, and inflection circles are discussed. This treatment is extended to the relative motions of three plane bodies. The application to the four-bar linkage, crosshead mechanisms, cams, and gear teeth yields fruitful results.

M. Goldberg, USA

1495. Kolchin, N. I., Determination of radii of curvature of cams in cam mechanisms by author's method for unround wheels (in Russian), *Trudi Sem. teor. Mash. Mekh.* **10,** 39, 16–21, 1951.

Two cams with circular followers are considered. The center of one of them moves in a prescribed circular arc; that of the other moves in a straight line not going through the center of the cam. Graphical constructions are given for the radii of curvature of the cams for every position of the follower. The instantaneous equivalent four-bar linkage is used to justify the construction. The advantage of the method is that it uses velocities and not accelerations.

A. W. Wundheiler, USA

1496. Hildebrand, S., On the design of cam mechanisms (in German), *Maschinenb.-tech.* **1,** 5, 203–216, Aug. 1952.

Paper presents concise and comprehensive compilation of kinematic data on cams, with main emphasis on velocities and accelerations characteristic for various types of disk-cam displacement laws. Design information on cam surface curvature, pressure angles, and follower linkage dimensions is included. While none of the information is new, paper gives very useful summary for cam designers, particularly relating to "inclined sine wave" displacement laws (sometimes termed "cycloidal" in the United States).

G. A. Nothmann, USA

Gyroscopics, Governors, Servos

(See also Revs. 1480, 1481, 1703)

1497. Malkin, I. G., On the stability of automatic control systems (in Russian), *Prikl. Mat. Mekh.* **16,** 4, 495–499, July/Aug. 1952.

The problem of determining the stability of the equilibrium point $x_j = 0$ of the system governed by equation $dx_s/dt = F_s(x_j) + \sum_j p_{sj}x_j$, $s = 1, 2, \ldots, n$; $j = 1, 2, \ldots, n$, where the characteristic root $s\rho_j$ of p_{sj} have negative real parts [AIzerman, *Avtomatika i Telemekhanika* **VIII,** 1947], may be reduced to the algebraic problem of determining the interval limits of the coefficients a_{sj} of the linear form $F_s = \sum_j a_{sj}x_j$, provided that the function

$$dV/dt = \sum_s (\partial V/\partial x_s)\,[F_s + \sum_j p_{sj}x_j] = W(x_j) + \sum_s (\partial V/\partial x_s)F_s$$

is definitely negative. $W(x_j)$ is an arbitrary definite quadratic form, while $V(x_j)$ is, according to Lyapunov, a determined definite positive quadratic form. This condition is satisfied if the limits of the interval a_{sj} are small quantities so that equilibrium is asymptotically stable within the region of allowed initial displacements limited by the surface of the largest ellipsoid from V, which are all contained in the region $|x_s| \leq A$.

Author analyzes the same problem, assuming $F_s < Q\sum_j |x_j|$, where Q = const. If $x_{sj}(t, t_0)$ is the system of basic solutions with $x_{sj}(t_0, t_0) = \delta_{sj}$, where δ_{sj} is Kronecker's symbol, there exists inequality $|x_{sj}| < Me^{-\alpha(t-t_0)}$, where M = const, $\lambda > 0$ the least value of $Re(\rho_j)$ and $\alpha < \lambda$. The equilibrium position is asymptotically stable within the region $|x_s^0| < \eta$ provided $Q < \alpha/Mn$, $\eta < A[(1/Mn) - (Qm/n\alpha)]$, $m \leq n$. In the case of arbitrary initial displacements, the region is extended up to $A = \infty$ where $\eta = \infty$. Solution $x_s(t)$, by the Cauchy method, satisfies the integral equation system.

Both methods are compared in an example; author states that in some instances his method yields more accurate results, while in other cases he recommends the AIzerman method.

D. Rašković, Yugoslavia

1498. Metelitsín, I. I., On the question of gyroscopic stabilization (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **86,** 1, 31–34, Sept. 1952.

In practice, mechanical and electromechanical systems usually are nonconservative. The Hurwitz criterion of stability is used in their stability investigation; however, it does not give a true picture of the relative influence of various kinds of forces.

Author deduces the stability criterion of a nonconservative system governed by the system of equation

$$\sum_k (a_{ik}\ddot{q}_k + \beta_{ik}\dot{q}_k + \gamma_{ik}\dot{q}_k + \delta_{ik}q_k + \epsilon_{ik}q_k) = 0$$

with

$$a_{ik} = a_{ki},\ \beta_{ik} = \beta_{ki},\ \delta_{ik} = \delta_{ki},\ \gamma_{ik} = -\gamma_{ki},\ \epsilon_{ik} = -\epsilon_{ki}$$

in the form: $4TE^2 - 2D\Gamma E < D^2V$. The kinetic energy T and (Rayleigh's) dissipation function D are definite positive quadratic forms, whereas V, Γ, E are real quantities representing

the action of conservative δ_{ik}, gyroscopic γ_{ik}, and "auto-unconservative" forces ϵ_{ik}. The above criterion yields six theorems which show the influence of individual forces as well as methods enabling the transformation of an unstable system into a stable one. The most important influence is that of the gyroscopic forces. If these are large, the frequencies separate into low frequencies and high frequencies, resisting forces being small for the former and large for the latter.

These theorems may be actually proved in practice on gyroscopic equipment.

There is some inconsistency in the subscript notation.

D. Rašković, Yugoslavia

1499. **Jones, S., The determination of the best form of response for a servo when an extraneous random disturbance is present with the error signal,** "Automatic and manual control," New York, Academic Press, 139–147, 1952. $10.

Paper gives a brief review of the mean square error criterion and its minimization as used by Wiener. The minimization integral equation is solved by a numerical method involving the use of finite difference operators. The author shows that the application of the minimum mean square error criterion calls for higher and higher servo band widths as the noise power becomes smaller. As the noise power becomes large in relation to the signal power, the closed-loop spectral response of the best servo tends to the same shape as the power spectrum of the input.

N. B. Nichols, USA

Vibrations, Balancing

(See also Revs. 1616, 1619)

1500. **Mitropol'skiĭ, Yu. A., Investigation of oscillations in nonlinear systems with many degrees of freedom and slowly varying parameters** (in Russian), *Ukrain. mat. Zh.* **1,** 2, 85–98, 1949.

Let there be given an oscillatory system with N degrees of freedom and let its kinetic and potential energies be represented by

$$T = \tfrac{1}{2}\,\Sigma a_{ij}(\tau)\dot{q}_i\dot{q}_j,\ V = \Sigma b_{ij}(\tau)q_iq_j$$

where $\tau = \epsilon t$, ϵ a small positive parameter, and $a_{ij}(\tau)$, $b_{ij}(\tau)$ are indefinitely differentiable for all $\tau \geqq 0$. Let the system be subjected to a small force with components

$$\epsilon Q_j = \epsilon Q_j{}^1(\tau, \theta, q, \dot{q}) + \epsilon^2 Q_j{}^2(\tau, \theta, q, \dot{q}) + \ldots$$

periodic with period 2π in θ, where $\theta = \theta(\tau)$ is indefinitely differentiable for all $\tau \geqq 0$ and $d\theta/d\tau = \nu \geqq 0$. The Lagrange system is

$$\frac{d}{dt}(\Sigma a_{ij}\dot{q}_j) + \Sigma b_{ij}q_j = \epsilon Q_i \qquad [1]$$

Together with [1] introduce the auxiliary system with constant coefficients depending on both τ and ϵ

$$\Sigma a_{ij}\ddot{q}_j + \Sigma b_{ij}q_j = 0 \qquad [2]$$

One assumes that [2] has N particular solutions

$$q_i{}^k = \varphi_i{}^k a\cos(\omega_k t + \alpha_k) \qquad [3]$$

where $\varphi_i{}^k$ and α_k depend on τ and ϵ. If one substitutes $\tau = \epsilon t$ in [2] and [3], [3] will only represent a solution of [2] in which frequency and amplitude vary slowly and will only be an ϵ approximation. One will now seek an asymptotic approximation to a periodic solution of [1] very near to one of the periodic solutions [3], say to the one corresponding to $k = 1$. It is assumed that the only solution of [2] corresponding to equilibrium is $q = 0$, and that no multiple $m\omega_1(\tau)$ is even for any τ equal to one of the $\omega_i(\tau)$, $i > 1$. A solution of [1] is now looked for in the form

$$q_i = \varphi_i{}^1(\tau)a\cos(s\varphi + \psi) + \epsilon U_i{}^1(\tau, a, \theta, s\varphi + \psi) + \epsilon^2 U_i{}^2(\tau, a, \theta, s\varphi + \psi) + \ldots$$

where the $U_i{}^k$ are periodic in θ and $s\varphi + \psi$ with period 2π and a, ψ are time functions satisfying a system

$$\dot{a} = \epsilon A_1(\tau, a, \psi) + \epsilon^2 A_2(\tau, a, \psi) + \ldots$$

$$\dot{\psi} = \omega_1(\tau) - \frac{s}{r}\nu(\tau) + \epsilon B_1(\tau, a, \psi) + \ldots$$

Moreover, $\varphi = \theta/r$ and r, s are relatively prime not too large integers which depend upon the particular resonance one wishes to consider. Everything revolves around the determination of the functions $U_i{}^k$, A_j, B_j. This is done essentially by substitution and identification of powers of ϵ, the determination being so made that $U_i{}^k$ contains no zero denominator. The details are left out as too complicated to be given here.

S. Lefschetz, USA

1501. **DeBaggis, H. F., Dynamical systems with stable structures,** Contrib. Theory Nonlinear Oscill. **2,** Annals Math. Studies no. 29, 37–59, 1952. $1.50.

Paper considers the dynamical system $dx_i/dt = P_i(x_1, x_2)$, $i = 1, 2$, in a closed region G bounded by a simple closed curve L with continuously turning tangent, and the P_i have continuous first partial derivatives inside and on L. The above system is called structurally stable if the perturbed system with right-hand side $P_i(x_1, x_2) + p_i(x_1, x_2)$ has the same phase portrait as that of the original system. In the first part, author establishes very general properties of trajectories and limit cycles of structurally stable systems. In the second part, sufficient conditions for structural stability in G are given. If L is a cycle without contact (the velocity of the vector field is not tangent to, nor vanishes on L) they are: (1) $\Delta \neq 0$; if $\Delta > 0$, $\sigma = 0$ where the characteristic equation is $\lambda^2 + \sigma\lambda + \Delta = 0$; (2) there are only a finite number of periodic solutions which are such that $\int_0{}^{t}[(\partial P_1/\partial x_1) + (\partial P_2/\partial x_2)]\,dt \neq 0$; (3) there are no separatrixes both issuing from and tending toward a saddle point. Paper contains nine theorems and eleven lemmas. In reviewer's opinion, this is an excellent contribution to greater generalization of results.

R. M. Rosenberg, USA

1502. **Johnson, D. C., Forced vibration of a rotating elastic body,** *Aircr. Engng.* **24,** 283, 271–273, Sept. 1952.

Effect of forced vibration on a rotating uniform shaft with internal and external damping is studied theoretically. A criterion for stability is given, but suggestion is made that nonlinear effects may limit instability. Theory is applied also to rotating disks acted on by periodic and constant forces. Brief reference is made to forced vibration of nonuniform disks.

R. N. Arnold, Scotland

1503. **Liénard, P., Graphic representation of the resonance of an oscillator used for the study of nonlinear systems** (in French), *Rech. aéro.* no. 29, 45–58, Sept./Oct. 1952.

Author discusses linear and nonlinear single-degree-of-freedom systems. The familiar linear equation $m\ddot{X} + r\dot{X} + KX = mX_0\omega_0{}^2 \sin \omega t$ is expressed in dimensionless form by replacing X/X_0 by x and letting $(\omega/\omega_0)^2 = y/x$ with $e = r/2m\omega_0$ where $\omega_0 = K/m$. Plot of y vs. x then results in an ellipse whose ratio of major to minor dimension depends on e. This plot when used in conjunction with an x vs. (ω/ω_0) curve permits graphical evaluation of the fundamental characteristics of the system.

This procedure is extended to systems containing nonlinear springs and linear damping, to those containing nonlinear springs and nonlinear damping, and to van der Pol's equation. Both first and second approximations are discussed with specific examples given.

Two other graphical representations, logarithmic coordinates in plotting x and y and the so-called circle of resonance, are also discussed.

Paper is particularly effective, since author starts with application of graphical technique to the well-known linear case.

W. J. Worley, USA

1504. Wilde, H., Accelerometers (in German), *ATM* no. 201, 229–234, Oct. 1952.

This tutorial paper reviews the principles of operation, construction, and calibration of accelerometers. A novel means of producing known peak impulsive acceleration is noted as due to Feldtkeller and Wilde [*Frequenz* **3**, 29, 1949]. The instrument is mounted on the flat base of an inverted cone of relatively large angle. The assembly falls freely in guides and is stopped by a bed of uniformly tamped sand. The peak acceleration depends on the height of fall and the depth of the penetration of the cone into the sand. The weight of the falling assembly, the angle of the cone, and the condition of the sand are claimed to be unimportant.

V. Salmon, USA

1505. Ferrandon, J., Propagation of vibrations in continuous deformable anisotropic media (in French), *Génie civ.* **129**, 17, 328–330, Sept. 1952.

Author derives velocities of propagation of waves by Hugoniot's method for surfaces of discontinuity. Application is given to the case of an elastic solid whose physical properties have axial symmetry. There are four distinct wave velocities which are correlated with the corresponding types of wave. No comparison with experiment is given and the paper is entirely theoretical.

J. M. Jackson, Scotland

1506. NcNown, J. S., On the excitation of oscillations of harbor waters under the ocean action (in French), *C. R. Acad. Sci. Paris* **233**, 1, 9; 21–23, 553–555, July, Aug. 1951.

It is a well-known phenomenon that in the dead water of a harbor, which is connected with oceanic water masses by a narrow passage, a periodic motion is excited by the periodic waves of the sea. This very complicated process can be described by a simple mathematical proposition. By linearizing the problem, presupposing the existence of a velocity potential φ dependent on time, and separating the harmonic-time-function, author derives the three-dimensional potential equation for φ as in the case of the classical treatment of standing waves on limited water masses. Boundary conditions prescribed are: The knowledge of grad φ for the time $t = 0$, vanishing normal derivative of φ at the rigid vertical walls as well as the kinematic surface condition $\partial^2\varphi/\partial t^2 + g(\partial\varphi/\partial z) = 0$ (z vertical local coordinate). The problem leads to the wave equation $\nabla^2\varphi + \omega^2\varphi = 0$.

A cylindrical basin is taken as a harbor model, the lateral walls of which are removed in the region $-\beta \leq \theta \leq \beta$ of the polar angle θ, thus satisfying the boundary conditions: $\partial\varphi/\partial n = 0$ for $\beta \leq \theta \leq 2\pi - \beta$ and $\partial\varphi/\partial n = V_0$ for $-\beta \leq \theta \leq \beta$; V_0 is the constant presupposed amplitude of the horizontal surface waves penetrating from the outside.

In the resonance case, $V_0 = 0$, thus the problem is reduced to the case already treated by Rayleigh and Bouasse. Furthermore, the numerical solution for the surface level of two nonresonant cases is given and compared with experimental values obtained from measurements in a basin (diam 320 cm, depth 16 cm, aperture angle $\pi/8$). The agreement seems to be very satisfactory.

M. Schaefer, Germany

1507. Storchi, E., Small oscillations of water contained in plane walls (in Italian), *Atti Accad. naz. Lincei R.C. Cl. Sci. Fis. Mat. Nat.* (8) **12**, 5, 544–552, May 1952.

The oscillations of an incompressible perfect fluid are studied analytically under the assumptions that the motion is slow, irrotational, and small compared with the depth h of the container. The walls of the container are two symmetrical planes inclined at angles θ and $(\pi - \theta)$, respectively, to the horizontal. A family of solutions is then found in which the fluid oscillates with a frequency $(g/h)^{1/2}$, and which exists if $\theta = m\pi/(2p)$, m and p being mutually prime integers.

B. A. Boley, USA

1508. Elias, I., and Gordon, R., Longitudinal vibrations of gas at ambient pressure in a rocket thrust chamber, *J. Amer. Rocket Soc.* **22**, 5, 263–268, Sept.-Oct. 1952.

The Rayleigh-Ritz method is used to determine the natural frequencies of gas vibrations in variable cross-section tubes. Calculations agree well with acoustic measurements. Questions concerning end corrections are discussed, but reviewer feels their neglect requires further justification. The form of the solutions is general and may be useful to acousticians. Application to the dynamic conditions of a rocket chamber are not made, but are indicated. This appears to be a formidable step.

R. W. Morse, USA

Wave Motion, Impact

(See also Revs. 1464, 1505, 1644, 1656, 1658, 1736, 1764, 1766, 1786)

1509. Satô, Y., Transformation of wave-functions related to the transformation of coordinates systems. II, *Bull. Earthq. Res. Inst., Tokyo Univ.* **28**, parts 3–4, 175–216, July-Dec. 1950.

Author treats a general coordinate transformation T $[\phi, \chi, \psi]$, where ϕ, χ, ψ are the Eulerian angles, and shows that T can be decomposed into three elementary operations Φ, W, and W'. Surface harmonics of the form $Y_n(\theta_0, \varphi_0) = \overline{P_n}^m (\cos\theta_0) \exp(im\varphi_0)$ are transformed, and the coefficients in the results are numerically computed for $n \leq 7$.

Appendix I has expressions of $\overline{P_n}^m (\cos\theta)$ in terms of the sine and cosine functions of multiples of θ. These are obtained as consequences of the formulas developed in the study. The various formulas obtained are also applicable to the discussion of relations between geographical and geomagnetic coordinates in the theory of geomagnetism. Appendix II describes the notations used.

Author mentions that the same problem has already been treated from the standpoint of the theory of rotation groups. However, the results in that theory have not been expressed in a form which is useful in practice, whereas the results obtained here have been. [See also AMR **4**, Rev. 3126.]

E. J. Scott, USA

1510. Namiki, M., A variational method for determination of the propagation parameter, *J. phys. Soc. Japan* **7**, 5, p. 533, Sept./Oct. 1952.

Author considers the one-dimensional wave equation [Toraldo di Francia, AMR **6**, Rev. 1305] on the assumption that the propagation function k^2 is of the form $k_1^2 + Av$ where k_1 and v are known functions of x, and A is an unknown constant. He establishes a

variational principle for A. By means of this principle a satisfactory approximation to the value of A can be found, for a given reflection coefficient, by using approximate expressions for u.

A. Robinson, Canada

1511. **Knopoff, L., On Rayleigh wave velocities,** *Bull. seism. Soc. Amer.* **42,** 4, 307–308, Oct. 1952.

The values of the Rayleigh wave velocities for materials which do not subscribe to the condition $\sigma = 1/4$ are determined. The deviations of the Rayleigh wave velocities from 0.9194 V_s are not great but are significant in the problem of the identification of seismic wave components at positions close to a source.

From author's summary

1512. **Horák, Z., General method of solving the problem of impact of rough bodies** (in Czech, with Russian and English summary), Anniv. Vol. Zdeněk Bažant, Praha, Technic.-Vědec. Vydavat., 69–83, 1952.

Author continues his previous work by seeking a general solution for impact of rough bodies. By primary assumptions, (1) velocity of relative motion small compared with acoustic velocities in bodies, and (2) small deformations, author derives four differential equations—variables are three displacements and angle of rotation about normal to plane of contact. Extended Hertz theory, including tangential and torsional displacements at region of contact, is employed. Equations are therefore given in terms of compliances of elastic bodies; thus, solutions are limited by present state of elasticity theory. "As soon as these problems are solved, the method will automatically comprise even the imperfectly elastic impact. . ." Author lists items requiring study (e.g., hysteresis, energy of elastic vibrations, etc.), and examines various conditions of rolling, slip, etc., between bodies. Future paper presenting experimental evidence to support theory is promised.

English summary amounts to condensed version of paper, thus enabling readers without knowledge of Czech language to follow the main text. H. N. Abramson, USA

1513. **Hoppmann, W. H., II, Impulsive loads on beams,** *Proc. Soc. exp. Stress Anal.* **10,** 1, 157–164, 1952.

Paper deals with reproducible test results for stress and maximum deflection in multispan beams subject to impact by a solid sphere. The effect of internal damping on the contribution of the higher modes of vibration influences the test results, but has not been included in the analytical treatment. [See Hoppmann, W. H., II, "Impact on a multispan beam," AMR **4,** Rev. 2822.] As many as 30 modes are considered to get agreement between test and theory during the first one-half millisec. Results are of limited quantitative usefulness in the shock design of engineering equipment. E. G. Fischer, USA

Elasticity Theory

(See also Revs. 1467, 1475, 1522, 1532, 1553, 1570, 1612, 1617)

1514. **Geiringer, Hilda, The general plane problem of the ideal-plastic isotropic body** (in German), *Öst. Ing.-Arch.* **6,** 4, 299–314, Sept. 1952.

A system of equations is obtained which includes plane stress of a ductile material and plane strain of a more general material. Mathematical properties of these equations are discussed, including elements of numerical integration. Paper contains some extensions of author's previous work [AMR **4,** Rev. 3548; **5,** Rev. 1382]. Interest is still primarily mathematical rather than engineering. P. G. Hodge, Jr., USA

1515. **Roop, W. P., and Orowan, E., Stress concentrations in steel under cyclic load,** *Welding J.* **31,** 10, 502s–504s, Oct. 1952.

Senior author discusses an earlier paper by Orowan [AMR **6,** Rev. 478] and raises a number of questions concerning (1) the relation of the tensile strength to the S-N curve, (2) the relation between the stress-strain curves for cyclic and monotonic loading, and (3) the effects of previous fatigue on higher and later maximum loads. An application to the behavior of ships is sought. Orowan's reply throws further light on these questions.

Marshall Holt, USA

1516. **Thum, A., and Richard, K., Investigation on the operating stresses of gears of different materials and under different loading conditions** (in German), *Schweiz. Arch.* **18,** 10, 309–321, Oct. 1952.

Paper contains a critical review of available experimental and theoretical results concerning gear strength. Bending strength, contact strength, and resistance to wear are discussed; material types and heat-treatment methods giving suitable hardness distribution are described. Operating loads at different contact positions are given, and dynamical loads due to vibrations and irregular shape are estimated. Bending and shear stress with stress-concentration factor for tooth fillet is treated for different tooth shape, and influence of tooth deflection is pointed out. Pitting and wear and its dependence on contact stress, slip, and lubrication are discussed. Paper finally deals with strain and stress limits, giving a critical comment of test methods.

S. Sjöström, Sweden

1517. **Wilterdink, P. I., Holms, A. G., and Manson, S. S., A theoretical and experimental investigation of the influence of temperature gradients on the deformation and burst speeds of rotating disks,** *NACA TN* 2803, 45 pp., Oct. 1952.

This paper reports the experimental confirmation of the theoretical calculations on rotating disks at high speeds, presented earlier by S. S. Manson [Proc. First U. S. nat. Congress appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 569–577, 1952].

Authors have run tests on parallel-sided disks, 10-in. diam by $^3/_4$ in. thick, of Inconel X which was chosen because it is age-hardenable, and more uniform short-time properties could be expected. The apparatus was arranged to spin the disks up to bursting speed with a range of temperatures from 70 F to 1440 F and temperature differences between rim and center from 0 F to 1290 F. The experimental results are quite extensive and the results were reproducible, so that the data and conclusions should be usable with confidence.

In their summary, authors state: "The agreement between the theoretical and experimental results was good over the wide range of temperature conditions investigated. Thermal gradients produced little reduction in burst speed of the disks which had high ductility; however, these gradients had a strong influence on the behavior of the disk during early stages of plastic flow. The loss in tensile properties of the material, caused by temperature of the material, had a greater effect in reducing the burst speed than the stresses set up by the thermal gradient."

This report is valuable for all those interested in the design of turbine or compressor wheels, particularly when subjected to high temperatures. A. O. White, USA

1518. **Lardy, P., The two-dimensional problem in the case of periodically varying temperature effects (Temperature distribution and thermal stresses)** (in German), *Publ. int. Assn. Bridge struct. Engng.* **12,** 201–219, 1952.

With an eye on problems of temperature stress in arch dams

and containers, author presents the differential equations governing a temperature field changing periodically with time as well as the corresponding equations for Airy's stress function. A particular stress function is derived.

Applications refer mainly to calculation of temperature field in a rectangle. The stress problem, in particular the problem of satisfying boundary conditions, is only slightly touched on. Discussion is restricted to orthogonal Cartesian coordinates.

H. Parkus, USA

1519. Galimov, K. Z., Invariant form of the continuity conditions of finite deformations (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **77,** 4, 577–580, Apr. 1951.

Using tensors, the Eulerian and Lagrangian forms of the equations of continuity for finite deformations are deduced from first principles. J. R. M. Radok, Australia

1520. Ôkubo, H., An approach for the torsion problem of a prismatic cylinder, *Rep. Inst. high Speed Mech., Tôhoku Univ.* **1,** 93–98.

Author solves Saint Venant torsion problem for a solid regular polygon with any number of sides and for a polygon with a central circular hole. A function, the conjugate of the warping function, which satisfies Laplace's equation for the interior of the polygon but not the boundary conditions, is chosen in polar coordinates. This function and the equation of the boundary, also expressed in polar coordinates, are then substituted into the boundary conditions and the resulting equation is expanded in a Fourier series. The vanishing of the Fourier series yields an infinite set of linear simultaneous equations for the unknown coefficients of the conjugate warping function.

Numerical values are given for a solid square and a hexagon and for a square with a circular hole. Results for the maximum stress and the torsional rigidity of each cross section are in good agreement with those of previous investigations.

The presentation of the solution would have been improved if all of the reasoning involved had been included. Doubts about the correctness of the solution are raised during a first reading of the paper because of the missing steps, although subsequent rederivation of the equations indicates that the method is, indeed, correct. Author also claims that his solution converges better than previous solutions. For a hexagonal section, however, the solution of twelve simultaneous equations is required, and even then, judging from the values of the coefficients given, it appears doubtful that a sufficient number of coefficients has been chosen.

P. Seide, USA

Experimental Stress Analysis

(See also Rev. 1612)

1521. Brock, J. S., The determination of effective stress by means of small cubes taken from photoelastic models, *David W. Taylor Mod. Basin Rep.* 829, 13 pp., Sept. 1952.

A method is developed for determining (point by point) the "effective stress" (uniaxial equivalent stress associated with the von Mises yield condition) in three-dimensional photoelastic models. Slices from "frozen" models are cut into small cubes and analyzed individually. Retardation and isoclinic measurements are made photoelastically in the three coordinate directions of the cubes. From these measurements, the effective stress is calculated. Directions of principal stresses are also obtained. Experimental verification of theory is presented.

W. D. Jordan, USA

1522. Heldenfels, R. R., and Roberts, W. M., Experimental and theoretical determination of thermal stresses in a flat plate, *NACA TN* 2769, 35 pp., Aug. 1952.

The suitability of resistance wire gages for measuring thermal stresses (strains) is investigated. The gages were first used on specimens under constant stress up to 12,000 psi and under constant temperatures up to 300 F, and found to drift very little in 30-min duration of test. The gages were next used on a plate that was brought to a definite steady state of nonuniform temperature. The temperature distribution was such as to make the problem analytically the same as that of the bending of a clamped rectangular plate under a line load uniformly distributed along the longitudinal axis. The experimental results were in good agreement with theoretical computations, indicating the suitability of the gages for measuring thermal stresses.

G. Pickett, USA

1523. Lambie, J. B., The counting strain gauge, *Engineering* **174,** 4515, 168–170, Aug. 1952.

A long-base strain gage is described which consists of a series of contacts, each of which is centrally located between pairs of mating contacts. Relative motion between the center and the outer contacts is caused by the strain actuating the instrument. Varying distances are provided between different contact points. The direction of strain determines on which side the contacts will be made, and the magnitude of strain determines the number of contacts closed. Each of the outer contacts has a counter in series with it which records once for each cycle of make and break. The record will then indicate the number of times the strain has exceeded each of a number of assigned values. A stepwise oscillographic trace of the strain can be obtained by a measure of the total current required by the counter units. The instrument is applied to determine the number of times the stress in certain aircraft structures has exceeded any given value for a given time of service. I. Vigness, USA

1524. Kawada, Y., and Fujii, H., Research on the mechanically amplified strain-meter, *Mem. Fac. Technol., Tokyo Metrop. Univ.* no. 2, 48–54, 1952.

Author describes the evolution of a mechanical strain gage having a gage length of 5 mm and a magnification factor of 1000. One scale division of 0.5-mm length corresponds to a strain of 10^{-4}. Calibration on a beam showed decreased hysteresis and improved performance with rollers and gears replaced by lozenges resting in V-grooves formed by crossed plates. Use of the gage was demonstrated by the measurement of strains produced in plates by welding. Results corrected for thermal expansion showed maximum strains occurred immediately after welding was completed, and that different strains were observed for welding done under the same conditions. B. L. Wilson, USA

1525. Stokey, W. F., Elastic and creep properties of stresscoat, *Proc. Soc. exp. Stress Anal.* **10,** 1, 179–186, 1952.

Values of Poisson's ratio and moduli of elasticity and rigidity at 76 F were determined for Stresscoat, nos. 1206 and 1202. Hollow tubes were made by dipping or spraying the Stresscoat to a gelatin base which was removed before test by warming. The thin tubes were tested in torsion, and values of deflection under a known torque, applied for a second or two, made possible the determination of the modulus of rigidity. Creep properties also were studied. Specimens tested as cantilever beams were made by dipping strips of tissue paper in Stresscoat and allowing it to dry. Specimens were cast by pouring melted Stresscoat into steel molds, to produce strips and rods. The latter were tested in torsion; the former were loaded as cantilever beams, with SR-4 strain gages used to measure longitudinal and lateral strains.

Values of the elastic constants vary with time. From tabulated results for no. 1206 Stresscoat at 76 F, the modulus of elasticity varies from 150,000 psi after drying 1 day, to 285,000 psi after a week. Poisson's ratio is 0.42 for the completely dry material. At the same temperature, moduli for no. 1202 Stresscoat are about 25% lower with Poisson's ratio about 0.45. Creep studies show that the recommended practice of allowing twice the time that a piece is under load for Stresscoat to come to equilibrium before applying subsequent loads should be changed to four times for greatest possible accuracy.

Reviewer believes that results are highly significant and will find direct application to a better understanding of behavior of this stress-measuring technique. E. O. Stitz, USA

1526. **Hauk, V., X-ray and mechanical measurements of deformations in cast iron** (in German), *Arch. Eisenhüttenw.* **23,** 9/10, 353–361, Sept./Oct. 1952.

It is assumed that the difference in the static and fatigue strength between steel and cast iron is due to the notch effect of the graphite flakes, embedded in the tough ferrite component and normally under compression. The total deformation is measured with mechanical strain gages, while, by the aid of x-ray measurements, only the elastic deformation of the ferrite in the surface layer of the test piece is determined. By comparing the results, it is possible to distinguish the elastic part from the total deformation and the difference between the deformation of the ferrite and that of the total structure. The tests were carried out in tension, compression, and bending. In accordance with the assumption, the deformations established from the x-ray measurements are smaller than those following from the readings of the strain gages. The x-ray measurements give rise to smaller tensile and larger compressive stresses than the strain-gage measurements. This is explained by the fact that the graphite flakes have no appreciable strength in tension, but a considerable strength in compression. All the discrepancies cannot be explained, however, and the author recommends further tests.

R. G. Boiten, Holland

1527. **Durelli, A. J., Lake, R. L., and Phillips, E., Stress concentrations produced by multiple semi-circular notches in infinite plates under uniaxial state of stress,** *Proc. Soc. exp. Stress Anal.* 10, 1, 53–64, 1952.

Values of stress concentrations for multiple semicircular external notches in wide plates, determined by photoelastic experiments, are given and critically compared with theoretical results by Maunsell, Ling, Weber and Neuber. It is shown that the stress concentration decreases with increasing number (1 to 5) of notches and decreasing values of l/d (distance of notch-centers/diam of notch). The importance of multiple notches was shown recently by other authors [Thum, A., Stevenson, O., *VDI*, Apr. 1950], and the present study is a very useful contribution in a tangible form.

Another merit of the paper is the excellent handling of the somewhat unusual technique of diffused light polariscope and of CR-39 model material, which has particular creep properties. Although both are known from previous works of the authors, this study presents an outstanding example of careful consideration of the inherent sources of error and overcoming them successfully, which shows the applicability of these rapid and simple photoelastic methods under expertly controlled conditions.

D. Vasarhelyi, USA

1528. **Guerra, G., Photoelastic determination of stresses in the supporting structures of the Madonna del Carmine church in Cagliari** (in Italian), *G. Gen. civ.* **90,** 7/8, 434–439, July/Aug. 1952.

The experimental study, made in a standard polariscope and using perspex (an acrilic resin produced in England) as the model material, gives good agreement with analytical results.

G. Herrmann, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1513, 1520, 1569, 1583, 1593, 1603)

1529. **Seely, F. B., and Smith, J. O., Advanced mechanics of materials, 2nd ed.,** New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1952, xvii + 680 pp. $8.50.

This is a second edition of a text, first published twenty years ago, consisting of six parts with the headings: Preliminary considerations; Special topics on the strength and stiffness of members subjected to static loads; Localized stress-stress concentration; Energy method; Influence of small inelastic strains on the load-carrying capacity of members; Introduction to instability—buckling loads. Three appendixes have the headings: A brief introduction to the mathematical theory of elasticity; The elastic membrane analogy for tension; Properties of an area. As compared with the first edition, most of the presented material has been revised and two parts, those on inelastic strains and instability, are new. The volume contains much valuable information for the student and the practicing engineer. Due to careful editing and the clear illustrative drawings, the appearance is excellent. In reviewer's opinion, the suitability of the book as a course text is somewhat hampered by the relative lack of connection between the various parts and chapters. But the authors, as they state in the preface, have found the repetition of detailed statements of ideas, principles, and methods beneficial for the student.

To append to a book on strength of materials an introduction to the theory of elasticity should be most welcome, such as to give the student a broader outlook on the field of mechanics. Reviewer notes an unnecessary and possibly misleading restriction of the term "elastic" in this appendix, where elastic strain is identified as small strain, and elasticity theory as a whole seems to deal with homogeneous and isotropic bodies only.

Also, reviewer regrets that the unprecise term "action," which has been in use in some older volumes on strength of materials, found its way into the present book as local action, buckling action, plastic action, bending action, etc.

G. Herrmann, USA

1530. **Csonka, P., Sloping flexure of prismatic bars** (in French), *Acta Techn. Hung. Budapest* **3,** 1/2, 247–256, 1952.

A simple graphical calculation of bending stresses and the position of the neutral axis in a cross section.

M. Kuipers, Holland

1531. **Lee, E. H., and Symonds, P. S., Large plastic deformations of beams under transverse impact,** *J. appl. Mech.* **19,** 3, 308–314, Sept. 1952.

Authors set up a procedure to determine the deformations by studying the approximate motion of the beam under the assumptions of negligible elastic strains and of "rigid body motion of segments of the beam joined at plastic hinges where the entire motion takes place." The equations are applied to a beam subjected to central impact to obtain the deformation during application of the load and afterward, with the kinetic energy of the motion being transformed into additional plastic deformation. Authors state that successive approximations must be used to solve the equations to obtain the deformations; only the first approximation is used for the particular problem in the paper.

B. E. Gatewood, USA

1532. Carter, W. J., and Oliphint, J. B., Torsion of a circular shaft with diametrically opposite flat sides, *J. appl. Mech.* **19,** 3, 249–251, Sept. 1952.

Relaxation technique has been employed for numerical solutions of title problem. Since results for very small flats are unduly laborious by relaxation method, Greenhill's hydrodynamic analogy is used to evaluate maximum stresses for such cases. Comparison is made with approximate solution of Okubo. Reviewer regrets lack of discussion of refinements of technique which are applicable to evaluation of maximum stress by relaxation method. R. E. Newton, USA

1533. Stüssi, F., Shear center and torsion (in German), *Publ. int. Assn. Bridge struct. Engng.* **12,** 259–266, 1952.

Paper is a complement to a paper published previously [AMR **5,** Rev. 2789]. Author presents an easy method for calculating prismatic slender bars with thin walls, single or multiple closed cross sections. In the case of bending, the influence of the secondary shear stress on the deformation of the cross section is neglected. Thus the shape of the cross section is assumed unchanged during the deformation of the bar when flexural loads are applied. However, when torsion is considered, the above assumption is not allowed, and the influence of the secondary shear is accounted for.

The torsional moment is treated as consisting of two parts, the primary and secondary. Each of these torques acts about its center, and the resulting shear center of the cross section is located between them. W. Ornstein, USA

1534. Mathews, S. T., and Tulloch, Helen A., Configuration of a wire towing a submerged body, *Nat. Res. Counc. Canada Rep.* MB-150, 4 pp., 3 figs., Sept. 1952.

Curves are given for determining the shape and tension of a light, flexible cable towing a body in a fluid. More comprehensive treatments of the subject are given in *David W. Taylor Mod. Basin Reps.* 533 and 687 [AMR **1,** Rev. 7; **4,** Rev. 4104]. L. Landweber, USA

1535. Petersson, O., Combined bending and torsion of I beams of monosymmetrical cross section. A non-linear theory taking into account the risk of lateral buckling, *Roy. Inst. Technol. Stockholm, Bull.* no. 10, 260 pp., 1952.

Author devotes two chapters of this monograph to explanation and derivation of equations for the deflections and twist of an I-beam of monosymmetrical cross section under combined bending and torsion. Equations take into account the interaction between distortions and applied loads and moments, such as is done for combined bending and lateral compression of a beam, and include effects of restrained warping of the beam cross sections. Approximations are made, by means of which a single fourth-order nonlinear differential equation for the twist of each cross section is obtained. The equation is shown to reduce to previously derived forms in special cases.

The following very lengthy chapter contains solutions of the equation for a simply supported I-beam and a continuous three-span beam of rectangular cross section, subjected to several loadings. Author discusses the effects of various approximations in the derivation of the basic equations, and concludes that very little error is involved.

In the fourth chapter, tests made to verify the theory are described, and comparisons of theory and experiment are made. In almost every case the agreement between theory and experiment is excellent.

Since the calculations involved in the solution of the basic differential are very lengthy, author outlines an approximate method of analysis in the fifth and final chapter. In this method the effect of twisting of the cross sections on bending of the beam is neglected, and the resulting simplified differential equation is solved. The numerical results are then corrected in accordance with tables and examples given by the author.

In summary, the monograph contains a tremendous amount of analytical and numerical work which would be easily recomputed and, therefore, represents a great saving to those structural analysts and designers interested in this problem. However, the results cannot be referred to as in a handbook but must be very carefully studied and understood before being used. P. Seide, USA

1536. Houghton, P. S., Gears. Spur, helical, bevel and worm London, The Technical Press, 1952, xvi + 390 pp. 50s.

Book is for draftsman, shop superintendent, mechanic, inspector, and engineering student on the usual forms of constant velocity gearing. Subjects discussed include action of spur, helical, bevel, and worm gears, fine pitch gears, internal gears, gear-blank proportions, materials, strength and wear ratings, cutting and finishing methods, production-time calculations, inspection, and trigonometry of involute. Author's intent is to offer an application manual of the established British and American methods of design; hence, book contains a wealth of tables proportions, and formulas, including British and AGMA standards, with many worked-out examples, but with little analytical development.

Text is marred by numerous typographical, grammatical, and other minor errors, and in some places seems to have been rather hurriedly assembled. Notation system seems rather cumbersome. Sections on production methods seem well done, and comparison of load-capacity calculations by different methods is worthwhile. Reviewer believes this book is good as a complement to Buckingham's more theoretical works and as a compact presentation of British and American practices, with emphasis on the former. D. K. Wright, Jr., USA

1537. Winter, W. T., Nomograph to simplify gear tooth calculations, *Prod. Engng.* **23,** 9, 205–209, Sept. 1952.

1538. Karunes, B., On the distribution of stress in a deep beam containing two equal circular holes, *Indian J. Phys.* 26, 4, 197–200, Apr. 1952.

Author uses bipolar coordinates introduced by Jeffery in 1921 to solve title problem when holes are equally spaced on each side of neutral axis. A numerical example is given in which the hole centers are about 4/3 times the hole radius from neutral axis. Maximum stress on hole boundaries occurs at points farthest from neutral axis, and is about 5/2 times stress with no holes. P. C. Dunne, England

Plates, Disks, Shells, Membranes

(See also Revs. 1517, 1522, 1556, 1558, 1571, 1580, 1581, 1584, 1610)

1539. Favre, H., and Gilg, B., Bending of a rectangular plate with linearly variable thickness (in French), *ZAMP* **3,** 5, 354–371, Sept. 1952.

Author expands deflection in power series $w(x, y, \lambda) = \Sigma\lambda^n w_n(x, y)$ $(n = 0, 1, 2, \ldots)$ where λ is proportional to (linear) taper of plate in thickness. Recurrence relations are obtained by substituting assumed series into variable-thickness plate equations to give successive "constant-thickness" plate equations with pseudo loadings.

Particular case of simply supported square plate under hydrostatic pressure changing in same direction as plate thickness

varies is carried out with numerical results through $n = 2$. For this particular case with 8:12 ratio of edge thicknesses, the convergence at $n = 2$ seems satisfactory for engineering purposes.
M. L. Williams, Jr., USA

1540. **Ashwell, D. G., The stability in bending of slightly corrugated plates,** *J. roy. aero. Soc.* **56,** 502, 782–788, Oct. 1952.

Author applies equations from previous paper [AMR **4,** Rev. 1069] to problem of bending of corrugated plate, whose humps run axially. Humps of general contour are handled by means of Fourier series expansion. It is found that, as the bending moment increases, the humps become flatter up to a critical point at which further axial curvature requires smaller moments. Approximately, this critical value of curvature is independent of the height of corrugations, as long as these corrugations are shallow.

Critical moment increases approximately with the square of the height-to-wave-length ratio for the humps. Results are given for sinusoidal, triangular, and more widely separated narrow corrugations.
H. J. Plass, USA

1541. **Vejvoda, Z., Stress analysis of thick cylindrical shell subjected to internal water pressure** (in Czech), Anniv. Vol. Zdeněk Bažant, Praha, Technic.-Vědec. Vydavat., 213–234, 1952.

Paper deals with plane-stress problem of a thick circular ring where inner circumference ($r = a$) is loaded by hydrostatic pressure, outer circumference ($r = b$) by (a) hydrostatic pressure, (b) cosine pressure on the lower half, (c) single force at the lowest point of circumference.

In case (c), exact method is compared with technical method. Author states that for $b = 2a$, the technical circumferential stress σ_θ determined by technical method is about 30% smaller than exact value.

Article contains several mistakes, and some calculations involving Fourier series are very complicated. These defects reduce the reader's confidence in the results.
M. Hampl, Czechoslovakia

1542. **Oniashvili, O. D., A contribution to the question of stability of a cylindrical shell under axial compression** (in Russian), *Soobshchen. Akad. Nauk Gruzin. SSR* **8,** 141–150, 1947.

V. Z. Vlasov [*Prikl. Mat. Mekh.* **8,** 109–140, 1944] revised the Kirchhoff-Love theory of shells, putting the differential equations in a symmetric form. Vlasov's theory is very general and theoretically can be applied to a shell of any form. Author of this paper applies Vlasov's theory to a cylindrical shell. Utilizing also the Galerkin method [ibid. **7,** 49–56, 1943], author obtains an eighth-order partial differential equation, the unknown function being the stress function. The equations of elastic stability of the shell are obtained from the afore-mentioned equation by variational methods. The equation is tested first on a ring compressed radially by a constant distributed load. Formula obtained for the critical load agrees with the well-known result derived otherwise. Then author solves the problem as described in the title, i.e., an axially compressed cylindrical shell of infinite length and then of finite length. In each case, symmetrical and nonsymmetrical buckling are treated separately.
Courtesy of Mathematical Reviews T. Leser, USA

1543. **Oniashvili, O. D., On the computation of the critical forces for certain cases of buckling of cylindrical shells** (in Russian), *Soobshchen. Akad. Nauk Gruzin. SSR* **8,** 227–234, 1947.

In the preceding review, author applied Vlasov's theory of elastic shells to the case of a cylindrical shell, derived for it a stability differential equation, and studied the problem of stability under axial compression. In this paper, author uses his stability equation and continues to study a cylindrical shell, examining the critical loads for the following cases: a lateral radially directed distributed load, a combination of lateral and axial loads, and twisting moments applied at the ends.
Courtesy of Mathematical Reviews T. Leser, USA

1544. **Kovalenko, A. D., The stressed state of a rotating conical shell with wall thickness varying according to a linear law** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **9,** 143–166, 1951.

Author considers a very flat hollow cone whose angle at the vertex is only a little less than 180°. Its thickness varies linearly according to the formula $h = h_0(1 - l/l_0)$, where h_0 is the thickness at the vertex, l_0 is the total length of an element at the middle surface, measured from the vertex to the point where the thickness h is zero, l is the variable length of an element corresponding to the variable thickness h. The wheels of turbocompressors and of some other machines have often a very similar shape. An identical problem was solved before by E. Honegger. The author of this paper admits that his solution is somewhat similar, but claims that it is much simpler.

The two partial differential equations for the displacements and the stresses are taken from the author's previous (unavailable) work ["The theory of the resistance of a turbine wheel," *Akad. Nauk Ukrain. SSR*, Kiev, 1950]. The author changes these equations into hypergeometric equations using a method referred to V. V. Golubev [Lectures on the analytic theory of differential equations (in Russian), Gostehizdat, Moscow-Leningrad, 1941]. The formulas for stresses, displacements, and bending moments found from the solutions of the afore-mentioned differential equations are given conveniently in terms of certain coefficients and hypergeometric functions. Numerical values of the coefficients for different values of χ (χ is a dimensionless number combining the ratio of the dimensions and the angle at the vertex, $\chi = l_0 \cot \alpha / h_0$) are tabulated. The graphs of the stresses and the bending moments plotted against l illustrate well the stressed state of the shell.

The solution of the problem shows that: (1) A rotating hollow conical shell is less resistant than a disk of corresponding dimensions. Even for small values of χ, which characterizes the influence of the conical shape, the maximum normal stresses increase rapidly; (2) in a shell with a circular central hole, the stresses at the inner edges increase 1.5–2 times; (3) the outer edges of a conical shell rotating in a field of central force are quite considerably bent. Therefore, in the design of a turbine the space between a conical wheel and the stationary parts should be carefully computed. The bending of the outer edge increases when χ increases up to 1.5–2, and then decreases again.
Courtesy of Mathematical Reviews T. Leser, USA

1545. **Zaid, M., Partially plastic rotating discs,** *J. aero. Sci.* **19,** 10, 697–704, Oct. 1952.

A solution for partially rotating disks is presented in the form of series expansion. The criterion used for yielding is the distortion-energy theory. The volume change in the plastic region is assumed to be that for the plastic-elastic boundary. Certain graphs are given in dimensionless form to facilitate computation for specific problems. Apparently, the inclusion of the finite volume change has no significant effect on the spread of the plastic region (as compared with a previous solution by Nadai and Donnell). The following error should be corrected: "These satisfy the condition that the change of volume equals $(1 - 2\nu)/E$ times the sum of the principal *stresses*" instead of principal strains.
C. C. Wan, USA

1546. March, H. W., and Smith, C. B., The flexural rigidity of a rectangular strip of sandwich construction, *For. Prod. Lab. Rep., U. S. Dept. Agric.*, no. 1505, 19 pp., 2 figs., Mar. 1949.

Author obtains formula for flexural rigidity of sandwich plate consisting of core and two unequal faces, all orthotropic. Exact two-dimensional plane strain elasticity theory is used, so that account is taken of shear deformation, a quantity often neglected in sandwich calculations. Author shows that formula reduces to one derived earlier for sandwich with equal faces. Formula indicates that shear deformation is most important when transverse shear rigidity of core is low. No numerical results are given. H. J. Plass, USA

1547. Norris, C. B., Ericksen, W. S., and Kommers, W. J., Supplement to "The flexural rigidity of a rectangular strip of sandwich construction," *For. Prod. Lab. Rep., U.S. Dept. Agric.* no. 1505-A, 31 pp., 12 tables, 7 figs., May 1952.

This supplement to Rep. no. 1505 (see preceding review) contains results of flexural tests on sandwich plates made of various face and core materials, and having various sizes. They are presented and compared with results given by formula of Rep. 1505. Agreement is good except for short beams or very weak cores. Improvement in analysis to fit these cases more precisely is included. H. J. Plass, USA

1548. Parfitt, G. G., A note on the measurement of damping in vibrating rods, *Brit. J. appl. Phys.* **2,** 11, 327–329, Nov. 1951.

Paper sets out to obtain an expression for dynamic elastic modulus and damping in terms of band width at resonance when these quantities vary with frequency. Results are in disagreement with those of Lethersich [AMR **3,** Rev. 1945] and Petlzer. Reviewer has found error in derivation of approximation of cos βl in Eq. [7], which affects expression for γ in Eq. [16], but does not invalidate divergence from paper referred to above. Author is publishing correction in later number of same journal.

K. H. Griffin, England

1549. Tumarkin, S. A., Calculation of symmetrically loaded tore-shaped shells by means of trigonometric series (in Russian), *Prikl. Mat. Mekh.* **16,** 5, 569–574, Sept./Oct. 1952.

Author develops the problem, discussed previously in the works of many authors of the USSR (Fedoseiev, Ponomariev, Zenova, and Novozhilov), for the case of arbitrary symmetric load, and solves it by means of trigonometric series only.

W. Wierzbicki, Poland

1550. Okubo, H., The influence of the form of corrugation, upon the strength of a corrugated plate. I, II, *Rep. Inst. high Speed Mech., Tôhoku Univ.* **1,** 69–86, 1951.

The problem of corrugated sheets acted upon by forces normal to the surface at the crest of corrugation is treated analytically by using the general theory of cylindrical shells. The form of corrugation is assumed to be composed of circular arcs of two different radii. Numerical calculations have been carried out for corrugated sheets fixed to rigid reinforcing plates. Results show that the strength of the corrugated sheet increases when the central angle contained by the two ends of the circular arc increases and when the difference of the radii of the two types of circular arc decreases.

Author also solves the case where the corrugated sheet is compressed by two parallel rigid planes such that the tangential force (friction force) and displacement are included.

T. H. H. Pian, USA

1551. Vaĭnberg, D. V., On the calculation of composite disks and plates under the action of concentrated forces (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **80,** 5, 721–724, Oct. 1951.

Author treats summation of trigonometric series appearing in the solution of the elastic problem. In the case when the rim is very thin, or when there is a considerable difference between the elastic constants of the rim and the interior, the series converge very slowly. In such cases, asymptotic summation proves to be efficient. F. I. Niordson, Sweden

1552. Grioli, G., Integration of the problem of statics of homogeneous plates of arbitrary thickness (in Italian), *Cons. Naz. Ric., Pubbl. Ist. Appl. Calc.* no. 339 = *Ann. Scuola norm. sup. Pisa* (3) **6,** 1/2, 31–49, 1952.

Author specializes his previous three-dimensional theory [*Ann. Mat. pura appl.* (4), **33,** 1952] to the title problem. Details are presented only for a thin isotropic plate of constant thickness with combinations of simply supported and clamped edges. The stress components are first expanded in infinite series in terms of Legendre polynomials of the variable x_3 in the direction of thickness of the plate. Each coefficient of this series becomes a function of two Cartesian variables x_1, x_2, chosen within the middle plane of the plate, and is expanded in infinite series of orthogonal polynominals of these variables. Such polynomials are constructed with the help of monomials $x_1^m x_2^n$ ($m, n = 0, 1, 2, 3 \ldots$) which are combined linearly by means of constants in such a way that each becomes orthogonal to all the preceding ones over the area of the middle plane of the plate. By substituting the obtained expansions of the stress components in the expression for the potential energy, the latter becomes an infinite series with unknown coefficients. When a finite part of this series is considered, its coefficients can be computed by solving the linear algebraic equations resulting from an application of the theorem of minimum of potential energy. Thus the stress distribution throughout the plate is evaluated. It is also shown that the obtained theory is more general than the classical thin-plate theory, to which it reduces when first approximation only is considered. In an example of a uniformly loaded square simply supported plate, the maximum deflection is found to be within 0.5% of the well-known value of the classical theory.

A comparison with an alternate method of constructing particular solutions that satisfy the differential equation and are combined by means of constant coefficients, which are computed by minimizing expressions defined from the boundary conditions [Bergman, *Duke Math. J.* **11,** 617–649, 1944; Krzywoblocki, AMR **1,** Rev. 1109; Zizicas, *J. appl. Mech.* **20,** 23–29, Mar. 1953], will be very interesting. G. A. Zizicas, USA

1553. Zizicas, G. A., Transient thermal stresses in thin isotropic elastic plates, *Univ. Calif., Dept. Engng. Rep.* 52.7, 53 pp., Apr. 1952.

Small-deflection theory is developed from consideration of forces both in transverse direction and middle plane of plate in order to include buckling problems. Elastic and thermal properties of plate are independent of temperature. Inertia and rotary inertia forces are included, but shear and structural damping are neglected. Temperature distribution varies with time and space. Equations are derived without averaging over plate thickness as done by Marguerre, but the same result is obtained, thereby confirming the procedure for elastic and thermal coefficients independent of temperature. Thermal buckling of rectangular panels and solution of equations by eigenfunctions are discussed. Graphs are given for critical compression of plates in two directions. Author is commended for very thorough presentation.

R. B. McCalley, Jr., USA

1554. **L'Hermite, R., The sectional method in slab theory** (in French), *Publ. int. Assn. Bridge struct. Engng.* **12**, 221–225, 1952.

Method is the same as that treated in last section of a previous paper [AMR **4**, Rev. 3836]. Second paragraph of previous review applies to present paper also.

W. H. Hoppmann, II, USA

Buckling Problems

(See also Revs. 1486, 1529, 1540, 1543)

1555. **Zizicas, G. A., Johnston, D. E., Revell, J. D., and Addison, J. V., Graphs for critical loadings of thin rectangular plates under compression in two perpendicular directions,** *Univ. Calif., Dept. Engng. Rep.* 52.8, 13 pp., 46 graphs, May 1952.

The graphs give the ratio of one of the compressive stresses to the critical value of the stress when the other is zero (Euler's critical stress) in terms of the ratio of the two perpendicular stresses. The parameter for the curves is the ratio of plate sides, which varies between 1 and 5. March's parameter for orthotropic plates is varied between 0.1 and 5.0. The value 1 of the parameter corresponds to isotropic plates.

M. G. Salvadori, USA

1556. **Woinowsky-Krieger, S., On the stability of rectangular plates stiffened by a point support** (in German), *Ing.-Arch.* **20**, 2, 106–108, 1952.

Using methods discussed in standard texts, author considers the buckling of a thin elastic rectangular plate under uniform edge thrust, the Navier boundary conditions, but with a point support at the center of the plate. Values of buckling load are calculated for two cases: (a) No deflection of the central support point and plate clamped there; (b) no deflection of the support point, and no resistance to rotation there. Results are compared in tabular form with the case of no central support for various ratios of lengths of sides of the plate. The results are in accord with intuition. An annoying dimensional constant is used.

W. H. Pell, USA

1557. **Labram, E. E., The influence of the method of stringer attachment on the buckling and failure of skin panels with square top-hat stringers** (abstract from author's thesis), *Aero. Res. Counc. Lond. curr. Pap.* 93, 6 pp., 1952.

The results of experiments to find the buckling and failing loads of panels with riveted and glued stringers are given, and the two methods of attachment are compared. In the case of buckling stresses, a comparison is made with theoretical results. It is concluded that the glued panels show noticeably higher buckling and failing stresses, but that failures tend to be more extensive.

From author's summary

1558. **Gossard, M. L., Seide, P., and Roberts, W. M., Thermal buckling of plates,** *NACA TN* 2771, 39 pp., Aug. 1952.

An approximate method, based on large-deflection plate theory, for calculating the deflections of flat or initially imperfect plates subject to thermal buckling is outlined. The method is used to determine the deflections of a simply supported panel subjected to a tentlike temperature distribution over the plate surface. Experimental results for a particular panel are in good agreement with the theoretical results for the range of temperatures and deflections considered in the test.

From authors' summary by H. J. Weiss, USA

1559. **DiMaggio, F., Gomza, A., Thomas, W. E., and Salvadori, M. G., Lateral buckling of beams in bending and compression,** *J. aero. Sci.* **19**, 8, 574–576, Aug. 1952 = (in Italian), *Atti Accad. naz. Lincei R.C. Cl. Sci. Fis. Mat. Nat.* (8) **12**, 5, 524–529, May 1952.

The total lateral buckling energy of a beam is calculated for three cases, (1) simply supported I-beam under unequal end moments, (2) simply supported, rectangular cross-section beam under unequal end moments and thrusts, and (3) cantilever beams of rectangular cross section under thrust and shear. The solutions of the three energy equations are presented by tables giving the coefficients for various ratios. F. B. Schneider, USA

1560. **Ebner, H., Theoretical and experimental investigation of buckling through vacuum of cylindrical tanks** (in German), *Stahlbau* **21**, 9, 153–159, Sept. 1952.

Buckling of closed cylindrical tanks under external pressure and axial thrust is treated as an eigenvalue problem in differential equations by method presented in Flügge's "Statik und Dynamik der Schalen." Results are simplified by algebraic approximations based on observation that the number of circumferential waves greatly exceeds the number of longitudinal waves, if tank is short and thin. Approximate analysis leading to a characteristic equation in form of a vanishing determinant is extended to cases in which thickness of shell is a step function of the longitudinal coordinate. Details are worked out for a shell with a single step in its thickness.

Theoretical results are compared with experimental data for brass and paper models. Theoretical buckling pressures are somewhat higher than observed values.

H. L. Langhaar, USA

1561. **Weber, C., Impeded torsional warping** (in German), *ZAMM* **32**, 10, 305–307, Oct. 1952.

In the title problem, the general solution for Θ (angle of twist per unit length) always has the same form for the various section types, and in its expression only one quantity changes, as a function of the section form. This quantity Timoshenko ["Strength of materials," 2nd ed., **II**, chap. VI] calls a^2 and the author α^2, with $\alpha^2 = 1/a^2$. This quantity being known, Θ is deduced and all the magnitudes involved therefrom. The author, deviating from the classical elastic analysis of stresses on the flanges and the web, determines α^2 by means of a simpler statement of the problem based on the principle of the minimum potential energy. The elastic energies by twist, by impeded warping, and the potential energy moment on the free end of the member are found; then, the minimum condition supplies a very simple value for α^2. The results are applied to a beam of I-shaped cross section. The method is elegant but requires previous knowledge of warping function $w = \Theta f(x, y)$, which cannot always be given for unusual sections. A. M. Guzmán, Argentina

Joints and Joining Methods

1562. **Baron, F., and Larson, E. W., Jr., The effect of grip on the fatigue strength of riveted and bolted joints,** *Bull. Amer. Rly. Engng. Assn.* **54**, 503, 175–190, Sept./Oct. 1952.

Double butt joints having a tension-shear-bearing ratio of about 1.00:0.75:1.50 were subjected to zero-to-tension cycles of loading or to fully reversed cycles of loading.

The investigation showed that the clamping force of a fastener was one of the most important factors affecting the fatigue strength of a joint. The fatigue strength of a joint increased with an increase in the clamping force of a fastener. The fatigue

strengths of the bolted joints were greater than those of the riveted joints. The fatigue strengths of the joints with hot-driven rivets were usually greater than those of the joints with cold-driven rivets. The degree of hole-filling for the cold-driven rivets was, in general, not sufficient to prevent serious slippages from occurring during the fatigue and static tension tests. The experimental efficiencies of the joints tested in static tension were about the same irrespective of the kind of fastener. The tests showed that experimental efficiencies of 80% or over can be obtained. From authors' summary

1563. Forkois, H. M., Conrad, R. W., and Vigness, I., Properties of bolts under shock loading, *Proc. Soc. exp. Stress Anal.* **10, 1, 165–178, 1952.**

As is generally known, shock loading investigates other physical properties than static and fatigue tests. Paper presents the experimental determination and test results of fracture strength and elongation for bolts when subjected to shocks that may be expected aboard combat-type naval ships. The bolts were of SAE 1020 cold-rolled steel. Their diameter was $^1/_2$ to $^3/_4$ in., lengths were 2 and $4^1/_4$ in., and they were constructed with straight and reduced shanks. Threads were of NF Thread Series. Tests showed the fracture strength to be about 1.3 times the static value. Necking occurs at greater strain. For longer bolts, having shanks with diameter equal to root-thread diameter, elongation was 1.5 times as much as under static conditions. Reduced-shank bolts neck in the shanks, straight-shank bolts in the threads. Stress raisers are of minor influence. Recommendations on the choice of initial tension are given. All results are valid for the tested bolts only. Additional work for other bolts and materials will follow. P. Kohn, Czechoslovakia

1564. Hempel, S., Nailed wood structures in industrial building (in Polish), *Inżyn. Budown.* **9, 8, 255–262, Aug. 1952.**

1565. Hartman, A., Results of aging tests on wood specimens glued with artificial resin glue, hardened at room temperature (in Dutch), *Nat. LuchtLab. Amsterdam Rap.* M.1883, 14 pp., 7 tables, 5 figs., 1952.

Structures

(See also Revs. 1515, 1518, 1528, 1560, 1611, 1624, 1752)

1566. Craemer, H., The bearing capacity of statically indeterminate structures made from materials without tensile strength (a new arch theory) (in German), *Öst. Bauzeitschr.* **7, 4, 5; 53–59, 75–81; Apr., May 1952.**

Author discusses the different stress distributions in statically indeterminate structures when the material is supposed to be without tensile strength but, under compression, acts as an ideally plastic material. A special investigation concerning the conditions of equilibrium and mode of failure of arches is presented.
C. J. Bernhardt, Norway

1567. Charlton, T. M., Analysis of statically-indeterminate structures by the complementary-energy method, *Engineering* **174, 4521, 389–391, Sept. 19, 1952.**

Article discusses the use of the complementary energy in place of the usual strain-energy concept for analyzing indeterminate structures. The relationships between complementary energy and strain energy are very clearly developed. This is the outstanding contribution of the paper. No advantages of the complementary-energy principle over the strain-energy concept are apparent. Indeed, none are claimed, except to suggest that the complementary-energy method may be more advantageous when applied to nonlinear systems for which the loading does not produce excessive distortion. Two examples are presented in an appendix.
F. L. Singer, USA

1568. Ferguson, P. M., Analysis of beam-and-girder framing with known column settlements, *J. Amer. Concr. Inst.* **24, 2, 77–84, Oct. 1952.**

Author uses the three-dimensional moment distribution technique for evaluating the effect of column settlements on bending moments and torques in a beam-and-girder grid. Starting with given column settlements, displacements at beam and girder intersections are estimated. Fixed-end moments are then computed, and a moment distribution is carried to the point where carry-overs become small. Equilibrium criteria are then utilized to obtain corrective displacements and the corresponding corrective fixed-end moments. The moment-distribution process is continued and corrective moments inserted until the latter become sufficiently small. This method can be used with minor modifications for the analyses of simple grids carrying external loads.

Author correctly points out that the neglect of the effect of the slab as a stiffening diaphragm and the difficulty of accurately evaluating the effect of creep limit the practical value of the results. H. Simpson, USA

1569. Farquharson, F. B., Model verification of the classical flutter theory as adapted to the suspension bridge, *Publ. int. Assn. Bridge struct. Engng.* **12, 147–163, 1952.**

Laboratory tests are described which have as their purpose verification of a flutter theory of suspension bridges proposed by Bleich [AMR 2, Rev. 464]. A basic flat-plate model was constructed such that the edge design could be easily changed to square, sharp, or rounded edges. In addition, girder webs of various depths could be attached to the edges. Flutter tests in a wind tunnel were conducted on these models, and the results were correlated with Bleich's theory. In addition, a series of tests were run on a $^1/_{75}$-scale section model of the Golden Gate Bridge. The results of these tests are shown to be in excellent agreement with predictions based upon parameters determined from appropriate tests on a section model of the bridge.
R. L. Bisplinghoff, USA

1570. Lin, T. C., and Whitehead, L. G., The St. Venant torsion problem for the hyperbolic airfoil cross section, *Univ. Wash. Engng. Exp. Sta. Bull.* **no. 118, aero. ser. no. 1, 108–111, 1951.**

The problem is solved by internal conformal transformation of the airfoil to a circle. The paper summarizes the development of an exact general expression for the torsion function, as derived in the first author's Ph.D. thesis at the University of London (1948). Reference is made to that thesis for solutions for displacements, shear stresses, and torsional rigidities, as well as for numerical examples. F. J. Plantema, Holland

1571. Heldenfels, R. R., A numerical method for the stress analysis of temperature-shell structures under nonuniform temperature distributions, *NACA Rep.* **1043, 20 pp., 1951.**

See AMR 4, Rev. 3222.

1572. Mansfield, E. H., Some structural parameters for an aeroisoclinic wing. A novel method of building an aero-isoclinic wing, *Aircr. Engng.* **24, 283, 263–264, Sept. 1952.**

The general theory of the elastic behavior of a single cell wing

stiffened with swept stringers has been developed previously [*R.A.E. Rep.*, Structures 52]. It was shown that the swept members introduce a measure of skewness which causes the wing to twist, as well as bend, under simple bending loads.

This note shows that, if the sweepback angle is not more than 35°, it is possible, by introducing swept stringers, to make a wing aero-isoclinic, i.e., such that the relative incidence of all sections does not change under bending loads.

From author's summary by P. Cicala, Italy

1573. Foulon, E., Calculation of mine dams. Simplified method (in French). *Bull. Centre Étud. Constr. Génie civ. Hyd. Fluviale* **5**, 3–65, 1951.

1574. Habel, A., Remark about the influence of creep and shrinkage of pillar concrete on the support pressures of continuous steel bridges (in German), *Stahlbau* **21**, 10, 189–190, Oct. 1952.

Using an approximate relation between the effective modulus of elasticity of concrete and time, author analyzes influence of axial compression of piers on deformation of continuous beams. In practice, this effect is very small compared with that of other types of foundation movements, e.g., due to settlement.

G. G. Meyerhof, England

1575. Nielsen, K. E. C., Loads on reinforced-concrete floor slabs and their deformations during construction, *Swed. Cem. Concr. Res. Inst., Roy. Inst. Technol., Stockholm, Proc.* no. 15, 112 pp., 1952.

Multiple-story construction with concrete slabs supported on bearing walls requires shoring from floor to floor. An analysis is developed for a 4-story building as successive floors are placed and lower shoring finally removed. When shores are removed under lower floors, slab bending stresses develop there as large as 253% of ordinary dead-load moments for simple slab supports, or 228% for built-in slabs. This disregards shrinkage and creep in concrete and moisture changes in formwork. Tests showed that moisture change in the formwork was an important influence.

Extensive observations were made on a commercially built seven-story building designed for a total load of about 145 psf (approx. 6.3-in. slab). The greatest load carried by a slab was twice the dead load, or slightly less, and occurred when the slab two stories above was placed (a maximum of two stories of shoring was kept in place.) More significantly, in one case, 90% of the slab weight was carried when the concrete was only 5 days old, 170% when 9 days old. Individual shores carried as much as 220% of their share of one floor load.

It was concluded that load distribution is primarily determined by elastic deformations. Plastic deflections during construction were from 3 to 6 times as large as dead-load elastic deflections. A minimum slab thickness not less than 0.020 of the span is suggested to limit deflections. P. M. Ferguson, USA

1576. Cowan, H. J., Inelastic deformation of reinforced concrete in relation to ultimate strength, *Engineering* **174**, 4518, 276–278, Aug. 1952.

Paper discusses the deformational response of concrete in the light of its inhomogeneous structure, and analyzes the effect of the nature of this response on the inelastic redistribution of bending stresses and of moments in indeterminate structures. On the basis of a survey of the work of several investigators, the conclusion is reached that the apparent "plasticity" of the concrete is the manifestation of a process of internal disruption of the material, starting far below the conventional "ultimate strength." As a result of this process, the essentially continuous, though inhomogeneous medium is gradually transformed into a granular mass, the deformational response of which in the limiting case would be the result of solid friction between the elements of the aggregate. Thus the volume concentration of the aggregate emerges as a significant factor in determining the character of the deformation of concrete, a conclusion that is borne out by this reviewer's recent experimental investigations. A. M. Freudenthal, USA

1577. Dews, N. A., Prestressed precast concrete footbridges, *Concr. Constr. Engng.* **47**, 8, 241–246, Aug. 1952.

According to this suggestion, a bridge may be fabricated at remote places from a series of T-shaped blocks; posttensioned steel members (either high tensile bars or cables) placed in holes and passed through the blocks are fixed at the center and anchored at the ends. A method of designing bridges of different spans for this type of foot bridge is shown, in which Magnel's design method and notation are used. P. W. Abeles, England

1578. Angeli, L., Circular cofferdam with arched wales (in Italian), *G. Gen. civ.* **90**, 9, 491–499, Sept. 1952.

Paper describes an economical cofferdam design consisting of timber sheet piling having the shape of a horizontal circular arch. One or more arched wales give support to the vertical timber planks. Water pressure favors closing of joints between planks and increases watertightness. Detailed stress analysis includes effect of "hoop stresses" between adjacent planks.

O. Hoffman, USA

1579. Paduart, A., Calculation of shell roofs without stiffening beams, *Concr. Constr. Engng.* **47**, 10, 297–299, Oct. 1952.

A reinforced-concrete vaulted roof built in Antwerp and covering an area of about 200 ft × 1500 ft is described, and several approximate methods of determining areas of reinforcement in the valleys are presented. Structure, lacking as it does any stiffening beams or interior cross walls, is unusual. Vaulting is formed by 4-span continuous arches of single curvature, each of about 50-ft span and 10-ft rise. Thrusts from vaulting are resisted by external counterforts. Interior support is provided by columns about 60 ft apart beneath each of the three valleys formed by abutting pairs of arches. Thickness of vaulting varies from 3 in. at crown to 5 in. in valleys.

Reviewer is of opinion that unequal snow or wind loading may prove dangerous despite the inherent strength of such shells under uniform loads, and a report on structure's performance under such loading is suggested as a future contribution.

A. H. Finlay, Canada

1580. Watts, G. W., and Lang, H. A., The stresses in a pressure vessel with a flat head closure, *Trans. ASME* **74**, 6, 1083–1090, Aug. 1952.

See AMR 5, Rev. 1063.

1581. Bergman, E. O., The new-type code chart for the design of vessels under external pressure, *Trans. ASME* **74**, 7, 1217–1222, Oct. 1952.

Paper presents a new code chart for shells and heads of pressure vessels under external pressure. The chart is especially adaptable to materials like nonferrous metals that have a nonlinear stress-strain curve. The curves for shells consist of two families with a common abscissa scale and different ordinate scales. One family represents the dimensional variables and is the same for all materials. The other family represents the mechanical property variables of a given material at different temperatures. Each curve is constructed from a stress-strain diagram of the material

at the temperature it represents. A "head-line" curve provides for the design of hemispherical heads.

From author's summary

1582. Piatti, L. J., and Villarreal, E. P., Exact calculation of a Vierendeel truss (in Spanish), *Cienc. y Técn.* **118,** 598, 129–142, April 1952.

Authors point out that, in a Vierendeel girder of n panels, there are $3n$ unknowns for the determination of which $3n$ equations can be written. They reduce the work of determining the unknowns to a consideration of four independent groups of simultaneous equations of $n/2$ or n equations each. In the case of a girder having parallel chords and an even number of panels, the work is further reduced. A study is made of the influence of axial and transverse deformations in the case of parallel chords and an even number of panels. J. P. Michalos, USA

1583. Klöppel, K., Direct determination of influence lines by the method of deformation values (in German), *Stahlbau* **21,** 8, 132–136, Aug. 1952.

Author presents a method of obtaining the influence line for a quantity (moment, shear, etc.) at any point of a continuous frame (not necessarily at a joint). Procedure consists essentially in cutting the structure at the point in question and applying on both sides of the cut (in opposite directions) unit loads of the same kind as the quantity whose influence line is required. The distortion produced in the structure is proportional to the influence line. Several theorems for simplifying the process are developed. M. P. White, USA

1584. Homberg, H., On the load distribution through shearing forces; theory of plate grid structures (in German), *Stahlbau* **21,** 10, 190–192, Oct. 1952.

This supplement to author's article reviewed in AMR **5,** Rev. 3397, and to his book on grid structures [AMR **5,** Rev. 1380], deals with the analysis of grid structures with torsion-resisting main beams and an infinite number of cross girders without torsional stiffness. The solutions are based upon the method evolved in author's previous article—they are given in terms of joint reactions, fixed-end moments, etc., of the cross girders, and in the form of influence areas for the internal loadings and deformations of the main beams. The solutions may also be used, as an approximation, for grid structures with a finite number of cross girders.

Author announces future publication of certain auxiliary values which occur in the analysis for facilitating the voluminous numerical computations. With such supplement, the method will prove useful. K. Arnstein, USA

1585. el Demirdash, I. A., Statics of the Vierendeel girder, *Publ. int. Assn. Bridge struct. Engng.* **12,** 125–144, 1952.

Different exact and approximate methods of analyzing Vierendeel girders are discussed. These include elastic weights, elastic couples, successive approximations, and panel methods. Analysis can be simplified if a constant ratio of stiffness is maintained between the two chords. Paper is confined to general aspects of the problem; no numerical examples are given.

R. B. McCalley, Jr., USA

1586. Yoder, E. J., and Lowrie, C. R., Triaxial testing applied to design of flexible pavements, Highway Res. Bd. Proc., 31st ann. Meet., 487–499, 1952. $7.50.

Triaxial tests were made on five subgrades (sand to clay) with a different compaction and rate of loading, and on two base course materials (stone and gravel) with different gradation and density. The effect of these variables on pavement thickness is shown as derived by the Kansas and Texas methods of analysis. While consistent variations are noted, use in Indiana requires empirical correlation with traffic, rainfall, and frost.

E. S. Barber, USA

1587. Loe, J. A., Dowel-bar joints for airfield pavements, *Proc. Instn. civ. Engrs.* **1,** 3, 612–650, Oct. 1952.

Paper reveals that the dowel-bar joints on airfield pavements are used to a more limited extent in Great Britain than in the United States. Author presents the results of investigation on the advisability of using dowel-bar joints, considering other alternatives and economical aspects. With a good list of references, the paper presents a good summary of previous investigations supplemented by recent laboratory and field tests. The conclusion is favorable to the use of dowel-bar joints as a load-transferring device. Although the author advances no new theories, he presents many data that would be of interest to a designer of rigid pavements. M. V. Smirnoff, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1514, 1515, 1531, 1545, 1576, 1617, 1631, 1637, 1780)

1588. Lomer, W. M., The yield phenomenon in polycrystalline mild steel, *J. Mech. Phys. Solids* **1,** 1, 64–73, Oct. 1952.

Article investigates over-all features of yield in polycrystalline material. Analysis is based on stress-strain curves for thin wires of recrystallized material, plus observations of Lüders' bands on bars with flat surfaces. Discussion of role of Lüders' bands on observed deformation is major portion of text. Reference is made to Cottrell's theory of impurity atmospheres in single crystals, but no attempt is made to utilize this theory in polycrystals. H. I. Fusfeld, USA

1589. Cottrell, A. H., The time laws of creep, *J. Mech. Phys. Solids* **1,** 1, 53–63, Oct. 1952.

Brief review of experimental and theoretical results on transient creep. Assuming a linear relation between activation energy and activation stress, a logarithmic law for the creep rate is derived from the exhaustion theory under very general assumptions as to the distribution of elements with activation energies in a given range. Experiments by Wyatt on polycrystalline copper [*Nature* **167,** p. 866, 1951] indicate that the elements in Wyatt's exhaustion creep are the cutting of one dislocation line by another. Quantitative conclusions can be drawn from this explanation. To explain the Andrade creep, modifications of the exhaustion theory, i.e., the redistribution of the elements during creep and the influence of some true work-hardening, are discussed briefly. J. Meixner, Germany

1590. Ferry, J. D., and Williams, M. L., Second approximation methods for determining the relaxation time spectrum of a viscoelastic material, *J. Colloid Sci.* **7,** 4, 347–353, Aug. 1952.

Authors state that, of the various methods which may be employed to specify the time-dependent mechanical properties of viscoelastic materials, the distribution function of relaxation times has proved to be particularly useful. They further state that, if the usual first approximation methods of determining the distribution function of relaxation times are applied to dynamic test results, the distribution function calculated from the real part of the rigidity sometimes does not agree with that calculated from the imaginary part.

A second approximation method was then proposed and applied to the dynamic test results of three samples of polyvinyl acetate

in 1, 2, 3-trichloropropane. In two of the three cases, use of the second approximation method yielded better agreement, whereas in the third case the agreement was not improved.

Reviewer would like to point out that there are other and simpler ways of specifying the time-dependent properties of materials [Hogan, M. B., "The engineering application of the absolute rate theory to plastics," *Univ. Utah. Bull.* 59, **43,** July 1952; Pao, Y. H., "An analytical theory of the creep deformation of materials," Ph.D. thesis, The Pennsylvania State College, Aug. 1952]. These other ways are equally capable of representing and correlating the behavior of such materials under conditions of constant stress creep, stress relaxation, dynamic loading, constant strain-rate tests and creep under combined stresses. On the other hand, the distribution of relaxation times concept is limited to the case of simple stresses. Y.-H. Pao, USA

1591. Hedgepeth, J. M., Theoretical distribution of slip angles in an aggregate of face-centered cubic crystals, *NACA TN* 2777, 32 pp., Aug. 1952.

When a polished and etched metal specimen is stretched, parallel sets of slip lines appear on the surface of the plastically deformed grains. The frequency distribution of the angle between the slip orientation of a grain and the direction of tension can be used to check physical assumptions underlying any mathematical theory of plasticity which is explicitly based on a polycrystalline model and uses slip as the mechanism of plastic deformation. A previous study of this sort [AMR **5,** Rev. 2031] showed that the physical assumptions of the theory proposed by Batdorf and Budiansky [AMR **2,** Rev. 1264] are only in very rough agreement with experiment. It was thought that the discrepancy is due mainly to two limitations in the theory, neglect of compatibility of strain, and the tacit assumption that only one slip mode exists for each grain.

In this paper, Hedgepeth (one of the authors of the previous study) removes one of the limitations by taking into account the fact that twelve slip modes are possible in face-centered cubic crystals such as aluminum, the material used in the experiment. The discrepancy between theory and experiment is reduced to roughly half what it previously was, but the errors are still appreciable. S. B. Batdorf, USA

1592. Johnson, A. E., and Frost, N. E., Rheology of metals at elevated temperatures, *J. Mech. Phys. Solids* **1,** 1, 37–52, Oct. 1952.

An account is given of the outline and progress of an examination of the general stress, time, and temperature dependence of the creep, plastic strain, and relaxation properties of several metals. Relations between stress and creep rate are obtained for tension, torsion, and combined stress under constant loading at various temperatures up to 550 C for steel, 200 C for aluminum alloy, and 50 C for magnesium alloy. Results are compared with various suggested rheological equations. Combined stress creep under variable systems of loading, fracture after creep under combined stress, time and temperature dependence of creep, the relation of relaxation to creep, time-independent plastic strain and fracture at elevated temperatures in short-time tests are all investigated as part of a program which is continuing at the Mechanical Engineering Research Laboratory, East Kilbride, England. Results so far obtained are discussed in relation to theory. A. D. Topping, USA

1593. Lucas, G., and Masing, G., Creep of spirals from aluminum wire (in German), *Z. Metallk.* **43,** 10, 341–349, Oct. 1952.

Measurements show validity of parabolic law $x = Ct^{\beta}$, where x is the extension and t the time. The two parameters C and β are correlated by a logarithmic law $\log C = p - q\beta$, where q and p depend on stress and temperature. The exponent β depends strongly on the heat treatment undergone by the specimen, probably in consequence of hardening or segregation of Si (0.09%) contained in the Al of the specimen.

From authors' summary by B. Gross, Brazil

1594. Markovitz, H., A property of Bessel functions and its application to the theory of two rheometers, *J. appl. Phys.* **23,** 10, 1070–1077, Oct. 1952.

By differentiating Bessel's equation, the author calculates the first few coefficients in a double series expansion for $J_m(\xi)Y_m(\sigma) - J_m(\sigma)Y_m(\xi)$. By its aid he is able to obtain corrections for the mass of the fluid in two viscometers, whose previous theory had neglected inertia. The reviewer cannot follow the mechanical part of the analysis, which by use of "impedance" and similar devices, eschewing the concepts of continuum mechanics, leads in each case to an ordinary differential equation.

C. Truesdell, USA

1595. McLoughlin, J. R., A recording stress relaxometer, *Rev. sci. Instrum.* **23,** 9, 459–462, Sept. 1952.

A recording stress relaxometer is described. This instrument measures the lateral deflection of bowed steel strips in the load-measuring element. The deflection is measured electrically by means of a linear differential transformer coupled to a recording potentiometer through an a-c electronic voltmeter. The recording stress relaxometer maintains the strain in the sample constant to 0.001 in. during complete relaxation of the stress. It can be used on materials with moduli ranging between 10^7 and 10^{11} dynes/cm^2. It is also suitable for use as a simple tensile tester.

From author's summary

1596. Schreck, C., and Wille, R., Remarks on the Weissenberg effect from the viewpoint of mechanics of continua (in German), *Kolloid Z.* **126,** 2/3, 98–102, May 1952.

Authors discuss "normal stress effect" in non-Newtonian fluids. Apparatus and techniques are described. I. M. Krieger, USA

1597. Holden, J., Plastic deformation features on cleavage surfaces of metal crystals, *Phil. Mag.* (7) **43,** 344, 976–984, 3 plates, Sept. 1952.

Paper is a discussion of the kind and amount of information that can be obtained by interferometer measurements on cleavage surfaces of single crystals. By measuring successive layers of cleavage surfaces of a crystal containing a twinned region, a complete three-dimensional picture of the region can be obtained. This picture will include not only the dimensions of the twinned region, but also the bending of the basal planes necessitated by the inclusion of the twin. In the same manner, kink bands can be investigated, and actual dimensions, such as the change in level of the surface at the kink and the width of the kink, can be determined. The method can also be used to measure the inclination of adjoining facets formed in the polygonization of slightly curved cleavage slices. E. A. Davis, USA

1598. Velasco de Pando, M., Plasticity; recent experiments and new theoretical deductions (in Spanish), *Rev. Cienc. apli.* no. 23, 481–496, Nov./Dec. 1951.

The various theories of the plastic behavior of metals [Prager, *J. appl. Mech.*, Sept. 1948] are, in general, based on the assumption of isotropy and volume constancy of the material. Stüssi has recently performed several experiments on tubular aluminum specimens subjected to a combination of internal pressure and

axial loading by which he intends to show that Poisson's ratio remains constant through both the elastic and the elastic-plastic deformation; he also has proposed [*Bol. Real Acad.* (Spain), 1951] a new theory of plastic flow that considers the anisotropy developing in the course of plastic straining.

Author has used this theory to analyze the stress case of internal pressure in a thick-walled cylinder plane using "stress-increments." C. F. Bonilla, USA

1599. Velasco de Pando, M., Plasticity; some clarifications and a correction (in Spanish), *Rev. Cienc. apli.* no. 25, 118–123, Mar./Apr. 1952.

Author revises his previous analysis (see preceding review) of the elastic-plastic deformation of a thick-walled cylinder under internal pressure using total stresses instead of "stress-increments." C. F. Bonilla, USA

1600. Welber, B., Measurement of the internal energy in copper introduced by cold work, *J. appl. Phys.* **23,** 8, 876–881, Aug. 1952.

An annealing calorimetric technique was employed to determine the amount of residual energy introduced by torsion in cylindrical specimens of copper. The heat energy supplied to the strained sample by an internal heating unit, and the resultant temperature increase when compared with a similar unstrained sample permit an evaluation of the quantity of stored energy. The experimental technique is similar to that employed by Quinncy and Taylor [*Proc. roy. Soc. Lond.* (*A*) **163,** 157, 1937], and is described in detail along with the various sources of experimental error. Authors found that over the range of deformations studied, equivalent to approximately 8 to 12 cal/g, the ratio of stored energy to the total mechanical energy expended in producing the deformation was essentially a constant. This means that the stored energy was not approaching a saturation value as the amount of deformation was increased.

A. D. Schwope, USA

1601. Kuvshinskiĭ, E. V., The equations of motion of an incompressible elastic-viscous medium (in Russian), *Zh. eksp. teor. Fiz.* **21,** 88–92, 1951.

It is shown that the results obtained by Frenkel ["Kinetic theory of liquids," Oxford, 1946] and Tyabin [AMR **4,** Rev. 160] in their solutions of motion of an elastic-viscous incompressible medium are incorrect due to an erroneous assumption of a commutative property of certain operators. The present author first introduces assumptions regarding the relative magnitudes of velocity and stress gradients and thus obtains operators possessing this property. He then discusses the special cases of quasi-stationary, nonstationary, and purely oscillating motion of the medium. It is shown that, in regions of small stresses, the elastic properties of the medium are important only in nonstationary processes. For stationary processes, with the exception of certain special cases, the elastic-plastic medium moves essentially as a viscous liquid.

Courtesy of Mathematical Reviews H. I. Ansoff, USA

1602. Swift, H. W., Plastic stability under plane stress, *J. Mech. Phys. Solids* **1,** 1, 1–18, Oct. 1952.

Paper examines conditions for instability of plastic strain under plane stress for a material conforming to Mises-Hencky yield condition and strain-hardening, according to a unique relationship between root-mean-square values of shear stress and incremental strain. Problems discussed include biaxial tension, cylindrical and spherical shell under internal pressure, hydrostatic bulge, and cylindrical shell pressing. Theory developed allows for effect of initial overstrain. The results for critical thinning of the hydrostatic bulge show general agreement with experimental work. J. Heyman, England

1603. Mii, H., Remarks on the plastic deformation of light-metal tubes, *J. Japan Soc. appl. Mech.* **5,** 28, 15–16, 1952.

The maximum shear-stress law is shown to give good agreement with published experimental data on the plastic expansion of a thick-walled aluminum tube subjected to internal pressure.

J. C. Fisher, USA

1604. Glikman, L. A., and Tèkht, V. P., On the question of the physical nature of the fatigue process (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **86,** 4, 699–701, Oct. 1952.

Authors describe experiments on carbon-steel and stainless-steel specimens. Preparation consisted of combinations of: *A*, subjection to various numbers n of cycles of alternating stress, above or below the fatigue limit; *B*, aging at 250 C; *C*, annealing at 650 C. Measurement consisted of: 1, Determination of fatigue limit F; or 2, x-ray determination of degree of lattice distortion D. $A1$, $AB1$, and $AC1$ all show dependence of F on n; curve $AB1$ is above the others and shows initial rise followed by slower fall. $A2$ gives D vs. n curve initially linear, but leveling off; the effect disappears in $AC2$; but curves $ACA2$ show more rapid change of D with n than do curves $A2$. Curves similar to $A2$ are obtained when A is replaced by static plastic strain, n by reduction of area. Authors interpret results qualitatively in terms of microscopic physical processes.

Wm. F. Brown, Jr., USA

Failure, Mechanics of Solid State

(See also Revs. 1515, 1562, 1592, 1597, 1604, 1732)

1605. Parkins, R. N., The stress-corrosion cracking of mild steels in nitrate solution, *J. Iron Steel Inst.* **172,** part 2, 149–162, Oct. 1952.

Evidence indicated that applied stress plays a more fundamental role than merely widening the crack. Cold plastic deformation increases the tendency to stress-corrode. Distribution of carbide in mild steels is found to be more important than carbon content. Although cementite particles in the grain boundaries are found necessary for stress corrosion, they are not attacked by the corrosive liquid. It is postulated that ferrite in the grain boundaries is the active material and that it is rendered active by the presence of cementite globules. Lattice distortion of grains and tendency to stress-corrode seem to be related.

A theory is proposed that distortion of grain-boundary ferrite is sufficient to make boundary regions anodic to the rest of the grain. W. J. Anderson, USA

1606. Volkov, S. D., Cohesive failure in compression of brittle quasi-isotropic polycrystals (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **85,** 5, 967–970, Aug. 1952.

Author derives mathematical conditions for formation of microscopic cracks by making certain assumptions about the statistical distribution of stresses in a polycrystalline aggregate. These assumptions are not clearly stated, but apparently the Boltzmann distribution law of statistical mechanics has been taken over, with the thermal energy kT replaced by an energy parameter associated with the internal stresses. (This device has been used successfully in magnetic domain theory; see Bozorth, "Ferromagnetism," 653–654, 1951; Stoner, "Reports on progress in physics," 13, 99–100, and 133, 1950. It has not been justified by means of any clearly formulated theoretical model. Reviewer

regards it as essentially empirical and believes that a sound statistical theory of internal stresses would be more complicated.) Author's subsequent reasoning is unclear at points. No quantitative test of his theory is made; his only concrete conclusions relate to the probable orientation of cracks formed in uniaxial tension and compression and in biaxial compression.

Wm. F. Brown, Jr., USA

1607. Cox, H. L., and Field, J. E., The initiation and propagation of fatigue cracks in mild steel pieces of square section, *Aero. Quart.* **4, part 1, 1–18, Aug. 1952.**

Cracks started at points of high tensile stress when the ratio of tensile range to shear-stress range was greater than about 1.6. Direction of the cracks was the trace of a plane of high shear stress when the tensile to shear ratio was less than 1.7. The metallurgical structure seemed to affect the detailed direction of cracks, but not their average direction. Reviewer has suggested that this may be a statistical effect due to random orientation of the grains. [AMR 5, Rev. 1085.] Authors found no single criterion of failure to account for the features of the cracks. Reviewer feels this may be due to size and shape effects in fatigue and the anisotropy of mild steel bars.

F. A. McClintock, USA

1608. Anonymous, References on fatigue, *ASTM*, STP no. 9-C, 1952. $1.50.

This is a list of references to articles dealing with fatigue, which were published in 1951. Ed.

1609. Palm, J. H., The effect of notches on the strength of aluminum alloys under static tensile loading, *Metalen* **7, 18, 309–316, Sept. 30, 1952.**

Results are presented of an experimental investigation focused on the materials 24S-T and 51SW. Variables treated were length and size of test bar, notch angle and depth, and prior compression. Author's data indicate that the fracture strength (1) decreases slightly with increasing length and size of test bar, (2) first decreases with decreasing notch angle and eventually increases again, (3) first decreases sharply with increasing notch depth and then increases again, and (4) decreases with increasing prior compression. Author attributes the size effect to a change in relative notch sharpness. Notch-angle as well as notch-depth effects are attributed to the probable initial predominance of the stress-concentration factor and later predominance of stress triaxiality. The depth effects, however, are not pure since the change of relative notch sharpness enters. Prior-compression effect is attributed primarily to increasing notch sharpness. Strain-hardening and residual stress are also involved here. Author gives short literature review and some correlation of present findings with that in quoted works.

J. Miklowitz, USA

1610. Holms, A. G., and Repko, A. J., Correlation of tensile strength, tensile ductility and notch tensile strength with the strength of rotating disks of several designs in the range of low and intermediate ductility, *NACA TN* **2791, 30 pp., Sept. 1952.**

The design of rotating disks is complicated by the difficulty in correlating the ultimate strength of the disk material as determined by pulling test bars, and the strength of the disk as calculated by the elastic stress theory. Burst tests have shown that high local stresses indicated by the elastic stress theory are rarely realized. It has been found generally that such peak stresses are relieved by plastic flow, and that, in many cases, the true strength of the disk is close to the value calculated by the average stress theory. Ductility of the disk material has been related to disk strength; the more ductile the material, the closer the true disk strength to that calculated by the average stress theory.

Burst tests were made on disks of different materials. Some of the disks were sound and some contained defects. Solid disks, disks with small central holes, and disks with large central holes were tested. The results were correlated on the basis of disk strength vs. ultimate tensile strength, ductility, and notch tensile strength of the sound material. It was found that the correlation of disk strength and notch tensile strength was more consistent and definitely superior to other forms of correlation.

In reviewer's opinion, the article is a valuable contribution to the solution of a difficult design problem. Data presented can be used to design lighter disks for a given application, which make it especially interesting to the aircraft gas-turbine industry.

E. G. Allen, USA

Design Factors, Meaning of Material Tests

(See Rev. 1631)

Material Test Techniques

(See also Revs. 1516, 1526, 1595, 1607, 1616, 1640)

1611. Hveem, F. N., and Davis, H. E., Some concepts concerning compression testing of asphaltic paving mixtures and subgrade materials, "Triaxial testing soils bitumin. mixtures," *ASTM Spec. tech. Publ.* no. 106, 25–45, 1951. $3.50.

Paper describes background and aims of the Triaxial Institute (T. I.), formed in 1947 in the United States by a group of men dealing with stability of bituminous mixtures, because clear-cut concepts directly applicable to design problems had been slow to develop, compared with knowledge of mechanical properties of more homogeneous materials of construction. Experimentation and accumulation of uncoordinated data had made it desirable to assess basic concepts, testing procedures, and performance records, as basis for further development.

In the asphalt field, several triaxial-test methods exist. Their use is based mainly on empirical correlation with road work, resulting in difficulties in comparing data obtained by different methods. Therefore, the scope of T. I. (also made a project committee of American Society for Testing Materials), was formulated as follows: (1) Clarification of fundamental mechanics of granular particles with viscous binder (including water); (2) investigation of triaxial compression test for measuring certain mechanical properties; (3) consideration of specific triaxial test procedures; (4) preparation of report (to Asphalt Institute) on specific application to bituminous mixtures. Because T. I. considers soils to be mechanically similar to bituminous mixtures, basic principles of latter apply to former, and, hence, no investigation of soils is made until conclusions are reached on bituminous materials. It was agreed to concentrate on triaxial type of testing because any other test, such as the unconfined compression test, would give poor correlation with performance.

Paper then records discussion on type of triaxial test, interparticle friction, use of Mohr diagram, and the nature and meaning of "cohesion." Very important for any stability test is the matter of compaction of test specimen. Various methods are discussed. Comparative results indicate linear relation between stabilometer and triaxial-test results, the first having great practical advantages, the second definite theoretical advantages. Two appendixes deal with derivation of formula for computing friction and cohesion from stabilometer tests with low height-diameter ratio samples, and with the stabilometer test method.

W. R. Schriever, Canada

1612. Sines, G., and Carlson, R., Hardness measurements for determination of residual stresses, *ASTM Bull.* no. 180, 35–37, Feb. 1952.

Authors demonstrate, by literature references and by their own experiments, that the apparent change in surface hardness caused by an applied compressive stress is very small compared to the change resulting from a tensile stress. Thus, they suggest that residual stress can be measured nondestructively by applying known stress until a discontinuity occurs in the hardness variation, indicating the transition through null stress. A simplified explanation of the effect of sign of stress on apparent hardness is presented. For biaxial stress states, the method is limited to determination of stress differences. For full utilization of the method, they suggest improved technique in hardness determination. S. S. Manson, USA

1613. Ripperger, E. A., Longitudinal impact of cylindrical bars, *Proc. Soc. exp. Stress Anal.* **10, 1, 209–226, 1952.**

Paper describes technique for measuring strains developed by longitudinal impact of a steel bar 10.5 ft long and $^3/_4$-in. diam. Impact velocities from 5.7 fps to 16.9 fps were provided by a second bar suspended to swing as a pendulum in a direction parallel to the length. Strains were measured by electric resistance strain gages mounted at four positions along the bar. Records were obtained by photographing the sweep on a cathode-ray oscillograph. Boundary conditions included an unrestrained bar, bar restrained at one end, bar clamped near struck end, bar clamped near midpoint, and bar embedded in sand. Experimental results are consistent with results predicted by elementary theory and results reported in other papers on wave propagation. P. G. Jones, USA

1614. Wright, P. J. F., and Garwood, F., The effect of the method of test on the flexural strength of concrete, with an appendix on the statistical aspect, *Mag. Concr. Res.* no. 11, 67–76, Oct. 1952.

Details of method of flexural testing studied are, (1) depth of specimen, (2) span/depth ratio, (3) rate of application of load, (4) central vs. third point loading, and (5) size of specimen.

Within the limits chosen, the effect of varying the rate of loading was fairly small. Modulus of rupture obtained from 8-in. deep beams was 30% lower than that from 3-in. deep beams. Central loading gives moduli 20%–25% higher than third point loading.

The results of the comprehensive series of tests reported are statistically analyzed, and it is shown that the variation of strength with size is largely explained by variations in the quality of the material, on the basis of what has become known as the "weakest link" theory.

An examination such as this of some of the factors involved in flexural tests should be of incalculable value to testing authorities, and this paper might well become a classic on size effects in concrete specimens. F. A. Blakey, Australia

1615. Schinn, R., Testing of heavy forgings for turbine and generator rotors through trepanning specimens (in German), *ZVDI* **94, 25, 837–842, Sept. 1952.**

Methods of determining soundness of turbine rotor forgings over the years from 1915 to 1950 are reviewed, and details of current practice are described. Increased service requirements called for higher strength materials which, in turn, compounded the difficulties associated with making large, heavy forgings. Thus, with increased probability of forging defects and heightened mass effects, it became necessary to develop more reliable as well as economical test procedures.

Earlier practice involved the analysis of a very few trepanned specimens from particular sections of the forging. Later, the number of samples was increased and still later, the principle of random location was introduced to increase the significance of the samples. Further increase in the size of rotor forgings made it advisable to develop a new technique to permit reducing the number of test specimens in the interest of lower inspection cost and structural soundness of the rotor. Thus the most recent technique involves the use of ultrasonic scanning of the rotor to identify those regions which should be included in a minimum sample. Trepanned specimens are obtained in directions consistent with rotor details and the defect to be investigated.

Current practice involves making standardized tests on trepanned specimens. The specimens are 18 mm in diam and are obtained with a 40-mm diam trepanning tool which is fed to a depth somewhat beyond the radial plane normal to the axis of rotation. The 18-mm core is subsequently pinched off and divided into several specimens representing properties at different diameters of the rotor.

The specimens cut from the trepanned core are subjected to the following types of analysis in sequence: (a) Ultrasonic oscillogram; (b) magnaflux; (c) Brinell hardness tests (at eight longitudinal positions); (d) metallographic specimens are prepared from regions giving positive indications in the magnaflux test; (e) a tensile specimen (12-mm diam) is prepared and tested with Martens mirrors for (1) stress at 0.2% offset or elongation, (2) tensile strength; (f) chips from preparation of specimens are given a chemical analysis for carbon; (g) impact specimens are made from the ends of the tensile specimen and tested.

This original paper gives complete results from tests made on fifteen rotors of varying size over the period from 1915 to 1950. It also includes a thorough discussion of forging seams and microstructure in relation to composition, forging practice, and heat treatment. L. V. Colwell, USA

Mechanical Properties of Specific Materials

(See also Revs. 1476, 1517, 1526, 1592, 1593, 1595, 1597, 1600, 1609, 1612, 1614, 1629, 1631, 1640)

1616. Hempel, M., Fatigue tests and behavior of materials at vibration stresses. I. Fatigue tests for creating a basis for mathematical investigations (in German), *ZVDI* **94, 25, 809–815, Sept. 1952.**

After reviewing the fundamental concepts about fatigue, author points out the possible limitations of these tests, according to the behavior of the material in the original pieces and its conditions for use, and recalls the tests on natural size structures made in the last few years. Author lists the factors responsible for fracture because of fatigue. He shows how they may be grouped into influence of size, of shape, and of the characteristic properties of the test specimen. The study of these factors should constitute the theoretical basis of these phenomena. He considers also a second group of variables corresponding to the effect of dynamic characteristics of solicitations, which should imitate the real conditions.

Dr. Hempel's actual work analyzes carefully the following factors: Conditions of the specimen's surface, including its polishing, its work-hardening and residual stresses; the effect of temperature, analyzed with the fatigue diagram, and comparing the dynamic endurance (fatigue) with statical endurance; then the effect of combined stress and notch effect (stress concentration).

A second part of this paper is to appear in a later issue of the same journal. S. A. Delpech, Argentina

1617. Jenckel, E., and Klein, E., The determination of relaxation times from the elastic rebound (in German), *Z. Naturforsch.* **7a**, 9, 619–630, Sept. 1952.

The temperature dependence of the rebound heights of steel spheres from polystyrene, polymethylmethacrylate, polyvinylchloride, and polyurethane was measured. A characteristic maximum in internal damping was found, corresponding to a minimum rebound height. A theoretical treatment based on combinations of plastic and elastic mechanisms was developed. The theory was used for determining the relaxation-time distribution and its temperature dependence from the data.

J. G. Leschen, USA

1618. Leviant, I., New mode of representation of fresh concrete (in French), *Tech. mod. Constr.* **7**, 7, 8; 209–214, 235–240; July, Aug. 1952.

Concrete is considered as a material consisting of three components, cement, water, aggregates. The well-known representation of the threefold mix ratio in a triangle is demonstrated, and its practical use is discussed. H. Craemer, Germany-Egypt

1619. Slibar, A., On the mechanics of the hexagonal ideal crystal (in German), Alfons Leon Gedenkschrift, Allgemeine Bau-Z., Wien, 68–72, 1952.

This is a survey of the paper "Zur Mechanik kristallinischer Stoffe" (on mechanics of crystalline solids), Veröffentlichungen des Dokumentenzentrums der Technischen Hochschule, Wien, 1951. Force components acting on an atom are set up as linear functions of displacements of nearest neighbors. Differential equations resulting in the limit of small distances and displacements, compared with equations of elastic medium, give relations between elastic constants of lattice and medium. Only a general method of calculation is described. As regards elastic constants of a polycrystalline solid, which can be obtained by averaging single crystal constants (influence of grain boundaries to be taken into account), author refers to paper of Slibar and Vitovec [AMR 5, Rev. 695]. A. Kochendörfer, Germany

1620. Grodzinski, P., Indentation hardness—its dependence on load, and a suggestion for a new definition (in German), *Schweiz. Arch.* **18**, 9, 282–292, Sept. 1952.

Author cites the recognized fact that indentation-hardness numbers, even though expressed in units of compressive stress, are not independent of load. This has been emphasized by recent work in the field of microhardness. He examines the validity of concept of hardness as load divided by area, and recommends a new definition based on the original Meyer relationship $P = ad^n$. New definition of hardness is that load which produces an indentation of unit dimension. This is based on the expression $h = Pd^{-n}$, where d is a quantity such as length, depth, area, or volume. Author cites ease of determining h by plotting P and d on double-log paper for two or more loads.

Author presents substantiating arguments for this approach, and presents data taken from Meyer's original work. He also cites work of Mitsche and Onitsch who advocate similar concept as result of experimental investigation. D. R. Tate, USA

1621. Gilard, P., Jr., Control of the composition and state of glass through measurement of creep under pressure (in French), *Rev. univ. Min.* (9) **8**, 8, 320–324, Aug. 1952.

Viscosity measurements on glass at room temperature are, in general, based upon rather difficult and tedious methods. Author suggests a new method that is based upon the fact that it is possible to produce permanent strains by using extremely localized heating at the center of a glass disk of equal thickness. Examination of deformation state of the disk is made optically by means of polarized light. Author tries to show that the different deformation distributions obtained are actually indicative of various compositions and structural states. The essential advantage of this method seems to be that tests can be carried out quite rapidly.

R. Nilson, Sweden

1622. MacDonald, D. K. C., Properties of metals at low temperatures, *Progress Met. Phys.* **3**, 42–75, 1952.

This article is an extensive review primarily of the specific heats and of the electrical conductivity of metals and alloys, and contains a list of 137 references, largely to recent work in the field.

Part I, on specific heats, includes brief reviews of the theories of Einstein, Debye, Blackman, and Raman on lattice specific heats, together with reviews of the theories and experimental results of the specific heat of electrons in metals and in the rare earths. Mention also is made of the possible contribution of internal transitions as developed by Schottky.

Part II, on electric conductivity, first reviews the Bloch-Grueneisen quantum theoretical development and gives an interesting and detailed summary of recent experimental work performed to check the theory. In particular, the recent experimental results on sodium obtained by MacDonald and Mendelssohn are of special interest. The review continues with a discussion of the theory of Barber and Mott with regard to transition elements, then of the anomalous minimum in the resistance of A_u at low temperatures, followed by a brief mention of the problem of superconductivity, and ends by reviewing the question of size effects on resistivity, as evidenced by recent d-c measurements at low temperatures and by high-frequency observations on the anomalous skin depth at low temperatures. The review is competently and authoritatively written and should provide an excellent survey of the field, together with valuable reference material. J. G. Daunt, USA

1623. Mosher, R. H., edited by, Technology of coated and processed papers, New York, Chemical Publ. Co., 1952, x + 733 pp. $15.

This book does not appear to contain information of any major interest to those in the applied mechanics field. About the only elements which would apply are the descriptions of certain test instruments for the experimental determination of the characteristics of paper, pulp, and other components. F. E. Reed, USA

1624. Fritz, B., Prestressed steel structures (in German), *Bauingenieur* **27**, 3, 99–100, Mar. 1952.

Magnel's system [AMR **5**, Rev. 2642] of prestressing tension numbers by cables of high-strength steel is further studied. Tables are presented showing savings of weight and cost for combinations of two structural steels with two high-strength steels, the basic parameters being the ratio of live to dead load, and relative magnitude of initial tension to the dead load on the member. It is pointed out that it may be disadvantageous to pretension the whole length of a lower chord with one set of cables; other practical difficulties are mentioned. P. S. Symonds, USA

1625. Fast, J. D., Strain ageing in iron and steel, *Philips Tech. Rev.* **14**, 2, 60–67, Aug. 1952.

Attempts are made to explain aging phenomena by migration of C and N atoms based on concepts in the theory of dislocations. Increase in hardness after cold-working or after punching is used as a criterion of aging. Author concludes that C and N pass into solution from precipitated carbide and nitride particles and flow toward dislocations. Experiments with iron containing only C or N as impurity indicated that after 40-hr heating at 50 C the

C did not cause strain aging, whereas N had maximum aging effect after 2 hr. Charpy experiments in the blue brittleness range also indicated N to have a greater effect on the properties of iron than C. Quench-aging was greatly influenced by the presence of manganese, but strain aging due to N was not affected by manganese. T. J. Dolan, USA

1626. Herold, P. G., and Knudsen, C., Flow characteristics of fire-clay refractories at high temperatures, *J. Amer. ceram. Soc.* **35,** 9, 220–225, Sept. 1952.

Several brick of intermediate duty, high duty, and superduty quality made by three different manufacturers were tested in the load equipment. The test brick was brought up to a temperature of 1400 C (2550 F) in 3 hr, soaked at this temperature for $^1/_2$ hr, and then pressure applied at the rate of $3^1/_2$ psi per min. Thus a pressure of 100 psi was applied in 30 min. The effect of P.C.E., porosity, and lamination cracks on flow characteristics is described. It is shown that the increasing-load test is more rapid than the constant-load test for determining flow characteristics.

From authors' summary

Mechanics of Forming and Cutting

1627. Epifanov, G. I., On two theories of metal cutting (in Russian), *Zh. tekh. Fiz.* **22,** 3, 467–473, Mar. 1952.

Author performed a series of cutting experiments with various materials in various liquid media; he then calculated the cutting force by the formula given by the school of Time, Zvorĭkin, Briks, and Usachev, and by the Kuznetsov formula. He finds that the values obtained by both formulas coincide equally well with the experimental data. At the same time he finds corroboration of the theory on the fluid action expressed in the articles reviewed in AMR **6,** Rev. 1286, and Rev. 1630 in this issue.

D. Mazkevich, USA

1628. Körber, H., Investigation of mechanical machining of spherical surfaces in optics by means of carbosilicon grinding disks (in German), *Feingerätetechn.* **1,** 5, 225–232, Aug. 1952.

The significance and aim of the paper are to investigate the conditions in which the carborundum disk can replace the diamond tool. It is shown how it is possible to rough mill, with carborundum disks, optical lenses so that the entire working process can be done mechanically.

From author's summary

1629. Trigger, K. J., Zylstra, L. B., and Chao, B. T., Tool forces and tool-chip adhesion in the machining of nodular cast iron, *Trans. ASME* **74,** 6, 1017–1025, Aug. 1952.

See AMR **5,** Rev. 1431.

1630. Epifanov, G. I., and Shreĭner, L. A., Influence of the active liquid medium on specific cutting work and longitudinal setting of the chip in free planing of metals (in Russian), *Zh. tekh. Fiz.* **21,** 12, 1518–1525, Dec. 1951.

The experiments consisted of planing aluminum, copper, iron, lead, tin, and zinc with HSS cutters having cutting angles of 58° and 68°. Authors investigated the efficiency of nonpolar kerosene; methyl-, ethyl- and heptyl-alcohol; oleic acid and ethyl laurate. Three tables are given.

Authors arrive at following conclusions: (1) They find confirmation of the opinion of P. A. Rebinder and his school [P. A. Rebinder, "Influence of active lubricating-cooling liquids on the quality of worked metal surface," 1946; AMR **6,** Revs. 920, 921, 1287], namely, that the liquid media have not only purely lubricating but also cutting effect. They found that, e.g., nonpolar kerosene has a definite adverse effect on iron, and carbon tetrachloride on lead, which cannot be attributed to their lubricating and, still less, cooling properties. (2) The cutting action of active liquids expresses itself in their capacity to transform a very small zone of the metal adjacent to the cutting edge of the tool into a peculiar brittle state, which leads to a detaching of the chip at a smaller degree of deformation of the entire cutting zone. (3) The change of the specific cutting work, under the effect of the active media, takes place parallel to the longitudinal setting of the chip. Authors conclude that the basic part of the work of cutting plastic metals is expended for plastic deformation of the cutting zone, the measure of which is the longitudinal setting of the chip. The relation between the cutting work and setting is well represented by Kuznetsov's [V. D. Kuznetsov, "Physics of the solid body," vol. 3, Tomsk, 1944] formula $\sigma_s = \sigma_0\eta^m$, where σ_s, conditional cutting stress, is dimensionally and numerically equal to specific cutting work; σ_0 is conditional yield point, η setting of the chip.

D. Mazkevich, USA

1631. Leyensetter, W., Deformation of chip and work surface in turning (in German), *Stahl u. Eisen* **72,** 19, 1139–1144, Sept. 1952.

This article reports the results of an investigation of foreshortening of the chip and residual strain of the work surface when turning several steels representing a range of strength. The controlled variables include cutting speed, rake angle, and tool material. The chip-deformation results are quantitative, while the work-surface results are given qualitatively in the form of photomicrographs; the former will be of interest to those concerned with the effects of strain rate and friction.

The investigation shows considerable sensitivity to strain rate. The shortest chips were obtained at the lower cutting speeds; smaller rake angles accentuated the effect of low strain rates. The high-speed steel tools produce greater foreshortening than did sintered carbide tools at the same speed and tool shape, apparently indicating lower friction with the carbide tools.

In general, greater deformation of the work surface accompanied greater chip deformation, as would be expected.

L. V. Colwell, USA

1632. Hirschfeld, M., The orifice profile of the wire-drawing die, its manufacture and maintenance (in German), *Werkstatt u. Betrieb* **82,** 1, 17–21, Jan. 1952.

Author discusses recent literature and research reports on diamond and sintered carbide dies. The question is considered as to where diamond and where hard-metal dies should be applied. Diamond is regarded as a questionable superior tool. For soft materials, Brazilian diamond is recommended; for hard materials, South African. Author reports that tests are in progress to determine the influence of crystal orientation on die performance. Generally, diamond dies are recommended for wire diameters of 2 mm and less, but sintered carbide dies from 0.05 mm upward are also known. Higher wear of sintered carbide causes more interruptions of drawing processes.

Correct form of die profile is very important. Standard projects for sintered carbide dies are outlined: Drilling and polishing of dies, as well as enlarging of worn dies. Means for measuring, in particular, the BISRA profilometer are described. Simultaneous application of diamond and sintered carbide dies in one machine are discussed. Reference is made to electromechanical production methods. P. Grodzinski, England

1633. Noritsín, I. A., Theoretical analysis of the sheet metal drawing process (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 11, 1696–1703, Nov. 1951.

Author solves differential equation for stresses in drawing of sheet metal, using the plasticity equation. He considers rolling and successive drawing operations, and finds that the solution permits determining formulas for the specific pressure flow for first and succeeding operations and for the determination of the maximum drawing forces. Formulas to determine optimal drawing coefficients take into account yield strength, deformation resistance parameter (considering hardening), radius of curvature of matrix, and metal thickness. Author concludes that his analysis shows that drawing process may be based scientifically on the degree of deformation of operation, geometry of working parts of stamp (punch and matrix), hardening intensity, and friction conditions. M. D. Friedman, USA

1634. Sims, R. B., The measurement of strip tension in tandem mills, *Engineering* **174,** 4517, 4518; 232–233, 262–264; Aug. 1952.

Author deals with the problem of measuring the tension present in a strip passing over an idling roller that is pressed with a certain force against the strip. This force causes the two branches of the strip, approaching and leaving the roller, respectively, to contact the roller under certain angles.

The tensions in the two branches of the strip are only equal if the deformation of the strip remains elastic when bent and passing over the roller. However, if the strip is plastically deformed in this process, a differential between these tensions develops. Calculations on the basis of the work consumed in such bending show that the tension differential increases as the applied tension becomes greater. Tests in which steel strip passed through an 85° bend over a roller and the tensions were measured, yielded satisfactory agreement with the calculations. This also applies to the stretching of the annealed steel strip that occurs in this process.

However, the tension differentials are small and can be neglected in order to determine the mean tension applied to the strip with the aid of a roller pressed against the strip. Such an interstand tensiometer developed by the author and installed in a tandem mill consists of three rollers over which the strip passes. The center roller is supported by two strain-gage-instrumented load cells. Experimentation on a prototype tensiometer yielded the (applied) tension within ±5%, and the accuracy possible with properly designed equipment should be within ±3%.

(This paper is one of the series based on rolling-mill investigations of the British Iron and Steel Association, which comprise an outstanding integrated program of plasticity research.)

G. Sachs, USA

1635. Graneek, M., and Wunsch, H. L., Pneumatic gauging applied to the measurement of surface finish, *Engineer, Lond.* **194,** 5043, 387–389, Sept. 19, 1952.

Details of a new, reasonably priced, high-sensitivity, and robust comparator are discussed. The comparator measures surface roughness of flat and cylindrical surfaces by a special, pneumatic measuring jet. Measurements on a series of ground and turned surfaces showed a reasonably linear relationship between air-gage and center-line-average readings. D. Kececioglu, USA

1636. Eggert, T., Investigation of various methods for determining profile corrections of form tools with reference to the attainable accuracies, *Technik* **7,** 10, 597–605, Oct. 1952.

In the first half of this paper, author discusses the well-known graphical methods for finding the profile of a circular form tool to produce a desired form on the workpiece. In the second half, the differential equation for the form is worked out in detail, an involved procedure when the tool has a finite rake angle, but resulting in a workable formula. The author suggests that, with zero rake-angle tools, the relatively simple analytical solution should always be used. When rake angles are finite and errors on the work up to 0.004 in. are permissible, he suggests using the graphical method, but prefers the analytical formula for calculating the tool profile when greater accuracy is required.

E. G. Loewen, USA

1637. Il′yushin, A. A., Model studies of hot and high-speed processes of metal-working by pressure (in Russian), *Prikl. Mat. Mekh.* **16,** 4, 385–398, July/Aug. 1952.

The process of operating on an object A with a tool B is studied by use of a scale model (A′, B′). The process involves either external heating or appreciable internal generation of heat. By examining all relevant equations of plasticity, thermal conduction, etc., author derives conditions that must be satisfied in order that model may faithfully represent full-scale behavior. In general, the number of these conditions is about 12 (author's numbering system makes a precise count difficult), but most of them are automatically satisfied if each piece in (A, B) is represented by a piece in (A′, B′) made of the same material. Then, if length L in (A, B) is represented by length L/n in (A′, B′), a process completed in time T in (A, B) must be completed in time T/n^2 in (A′, B′). In impact experiments, energy delivered per unit volume must be the same for A′ as for A.

Wm. F. Brown, Jr., USA

1638. Opitz, H., and Kob, J., Optimum values, cutting forces, and cutting temperatures in milling with tungsten carbide tools (in German), *Werkst. u. Betr.* **85,** 3, 81–85, Mar. 1952.

Authors present basic information regarding tool-work-thermocouple as affected by cutting speed and temperatures. Chip formation is correlated with tool temperatures. Oscillograph studies permit evaluation of temperature and tool force during the cut of a single chip segment. Tool wear for different types of chips and deflection of cutter teeth in relation to overhang is also illustrated. A. O. Schmidt, USA

1639. Schmidt, A. O., Metal cutting temperatures and tool wear, *Tool Engr.* **29,** 1, 2; 33–35, 51–54; July, Aug., 1952.

Reviewing previous publications on temperature and heat conditions in metal cutting, author explains the effect of cutting speed, speed, and other pertinent factors on temperatures in workpiece, chip, and cutting tool, and clarifies the interrelationship between these somewhat confusing problems.

Reference is made to recent work by author, Bickel and Widmer, Schallbrock et al., and Trent, and to the Reichel thermoduo principle for evaluating cutting temperatures and machinability. Tool wear is studied, and conclusions are drawn for best possible selection of feed and speed for practical applications. Work on steel and light alloys is covered.

Bibliography includes selected papers of older date and a complete list of recent papers. E. K. Henriksen, USA

1640. Wagner, G., Machinability of carbon steels when turning with light cuts (in German), *Stahl u. Eisen,* **72,** 19, 1144–1149, Sept. 1952.

Laboratory tool-life tests of short duration with constantly increasing cutting speeds for one HSS tool gave results in good agreement with cutting-speed data established in practice and usual tool-life tests. Cutting speed is increased by increments of 16 fpm after each 82 ft of cut for the single-point tool-turning steel test bar. Results are tabulated for various free-machining

steels, including American types, and tool steels. Tools tested include HSS and tool steel. A. O. Schmidt, USA

1641. van Santen, G. W., An electrical roughness tester for the workshop, *Philips tech. Rev.* **14,** 3/4, 80–86, Sept./Oct. 1952.

Author describes an instrument giving an indication of roughness measured electrically. This instrument was designed for the workshop in the first place and not especially for the laboratory, as are the expensive roughness meters already in existence. From author's summary

Hydraulics; Cavitation; Transport

(See also Revs. 1474, 1767)

1642. Formica, G., Note on overflow profiles of gradually varying steady streams flowing in cylindrical galleries (in Italian), *Energia elett.* **29,** 8, 480–491, Aug. 1952.

Author studies the backwater curves of steady flow in closed conduits, for which the usual theory of uniform flow implies a maximum for the discharge. The differential equation of the flow is analyzed, and anomalies are found for backwater curves in the field of depths higher than that corresponding to maximum discharge; in particular, a new asymptote appears, and consequently a new branch of the curve, which can determine the obstruction of the conduit and the formation of pressure flow. Hypotheses of the theory are discussed and numerical examples of calculation are given. D. Citrini, Italy

1643. Le Nobel, J. C., The movement of wing gates (in Dutch), *Ingenieur* **64,** 40, B.149–B.153, Oct. 3, 1952.

Formerly, several locks in the Netherlands used wing gates. Now again, the Zuiderzee-works, because of special circumstances, are going to apply them for a few locks in view of their advantages compared to other types of lock gates. The paper mainly concerns the calculation of the water resistance in consequence of the stowing in the wing box when the gate is moved in water without level difference, which determines the moving power needed. The method of calculation is specifically exemplified.

Reviewer's opinion: The basic assumptions about water resistance against movement are too simplified. The precision of the calculations, therefore, is somewhat misleading.

From author's summary by H. J. Schoemaker, Holland

1644. Dressler, R. F., Hydraulic resistance effect upon the dam-break functions, *J. Res. nat. Bur. Stands.* **49,** 3, 217–225, Sept. 1952.

The dam-break solution was given by Ritter in 1892, using the nonlinear shallow-water equations but neglecting resistance. Adding to these equations the Chezy resistance formula and reducing the two partial differential equations of the first order to one of second order (with elimination of one between the two unknown functions), we obtain from the characteristic theory that the wave front will maintain the same propagation velocity because resistance appears in the terms of first order of the equation and propagation velocity depends on the terms of second order only. This is a well-known theorem. Author's main result is, instead, that except at the tip, resistance raises the water surface and lowers velocities. It is obtained by applying the characteristic theory directly to the two differential equations of first order. In this way, the characteristics (which depend on two unknown quantities) are, in fact, themselves unknown, and author determines only some points of these and obtains some quantitative results by expansion into series. Formulas obtained agree sufficiently well with experiments. G. Supino, Italy

1645. Blench, T., Flow formulas of practical hydraulics (French and English), *Houille blanche* **7,** 4, 591–613, Aug./Sept. 1952.

Flow formulas for rigid pipes and channels are discussed and classified along with that for channels that form their solid boundaries from material differentiated out of the water-sediment complex. A single general flow formula is indicated, convertible into the formulas for the three special cases by proper expression of the term measuring equivalent roughness height.

From author's summary

1646. Roscoe, R., The viscosity of suspensions of rigid spheres, *Brit. J. appl. Phys.* **3,** 8, 267–269, Aug. 1952.

According to measurements of Eilers and Ward and Whitmore, relative viscosity of suspensions of smooth rigid spheres does not depend on the viscosity of the suspending liquid and the size of the spheres; but, as opposed to Einstein's law, it varies with the size distribution of the spheres. To explain this behavior, author supposes that with regard to spheres of any size, the liquid including the spheres of smaller size can be considered as a homogeneous liquid, so that the addition of these spheres increases the viscosity according to Einstein's law. Based on this assumption, author attains an equation for the limiting case of extreme diversity of sizes: $\eta_r = (1 - c)^{-2.5}$, η_r is relative viscosity, c volume concentration of spheres. This very well represents the observations made by Eilers on a suspension of spheres having a wide range of sizes.

Yet, also, the results of viscosity measurements on suspensions of spheres with nearly uniform size, performed by Ward and Whitmore, show a conduct deviating from Einstein's law. Author, following the trends of Vand, supposes that due to the collisions of the spheres at higher concentrations, appreciable numbers of temporary doublets, triplets, and aggregates of higher orders are formed. Therefore, a suspension of spheres with nearly uniform size behaves as a liquid with spheres of very diverse sizes, so that the above formula is applicable to that case too. Because of the liquid which is enclosed between the aggregates and so is immobilized, the 1.35 fold concentration must be inserted. The resulting formula $\eta_r = (1 - 1.35c)^{-2.5}$ is in good agreement with the measurements by Ward and Whitmore.

U. Rost, Germany

1647. Höppler, F., On new measurements of water viscosity (in German), *Z. angew. Phys.* **4,** 8, 297–299, Aug. 1952.

Author has devised a new type of viscosimeter, a rheoviscosimeter, which is different from the common capillary type. The principle of this new one is to time the rate of descent of a sphere through a cylinder filled with fluid whose viscosity is desired. By means of this new device, author has obtained a value for viscosity of water at 20 C as 1.0080 cP, and a ratio of air to water viscosity of 1 to 55.37. Author claims results are accurate to 0.1%. J. Marcus, USA

1648. Rockwell, R. A., Valve rangeability, *Instruments* **25,** 8, 1074–1079, 1126, 1128–1130, Aug. 1952.

Author states that the definition of rangeability as the ratio of maximum to minimum controllable flow is meaningless unless the valve-flow characteristics are defined. Rangeability is calculated from those maximum and minimum flow rates between which the desired characteristics are maintained. He defines valve sensitivity as percentage of flow change per unit lift change. Equal percentage valves have practically constant sensitivity within the flow-rate limits, while linear valve characteristic involves wide changes in sensitivity. The appendix proves that, for equal-percentage valves, the rangeability R is the number for which

$\log_e R = a \times Y_{max}$. It shows how to calculate the contours of theoretically equal percentage ports. Author emphasizes that, in practice, the rangeability of large equal percentage valves is relatively low (15 to 1), although if slight variations in sensitivity are admissible, 50-to-1 rangeability can be achieved. Minimum controllable flow is limited by leakages, while the maximum flow is determined by the system in which the control valve is installed.

Basic standards of valve testing must be established before unique definition for rangeability can be formulated.

N. Sag, Australia

Incompressible Flow: Laminar; Viscous

(See also Revs. 1462, 1473, 1484, 1644, 1646, 1681, 1695, 1759)

1649. Yeh, H., and Wang, C.-J., Potential flow in a space bounded by two torus surfaces, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 171–183, 1952. $6.

Exact solutions for potential flows in a toroidal space bounded by two torus (anchor ring) surfaces with one surface completely inside of the other are obtained through the use of toroidal functions. By comparing these exact solutions with their corresponding two-dimensional exact solutions, one can obtain an empirical rule whereby the potential flow in a toroidal space of more or less arbitrary geometric proportion (whose solution is therefore difficult to obtain otherwise) can be approximately estimated from its two-dimensional counterpart. Such solutions may give an indication on the meridional flow in a torque converter, if the free vortex type of blading is used throughout.

From authors' summary by H. R. Lawrence, USA

1650. Keulegan, G. H., Determination of critical depth in spatially variable flow, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 67–80, 1952. $6.

In a channel of small inclination and charged with a spatially variable flow, the critical depth is at the lower open end of channel. In augmenting the channel inclination, the position of the critical depths moves upstream. Using elementary notions of momentum and energy, a criterion is derived for the position of the critical depth. The usefulness of the criterion is examined by referring to some unpublished experimental results of Beij on flow in roof gutters. In the examination, it is noted incidentally that the law of resistance for the spatially variable discharges is at variance with laws ordinarily ascribed to the constant discharges in open channel.

From author's summary by G. E. Nitzberg, USA

1651. Kravtchenko, J., Note on the approximate solutions of the determinate problem of wakes (in French), *Ann. Inst. Fourier, Univ. Grenoble* **3,** 287–299, 1952.

Author introduces to French readers a new method by J. M. Rapoport, published in the *Math. J., Ukraina* **II,** 1950. The two-dimensional current in an incompressible fluid around a symmetrical rigid obstacle and the wake behind it are to be calculated.

In an ingenious way, Rapoport has varied the well-known method of Levi-Cività and others, in which holomorphic functions of complex variables were used. The author has made the investigation more complete, searching for the conditions for the method to give physically correct results.

Rapoport supposed the front side of the obstacle to be rounded; the fore edge alone may be sharp. The author extends the method to cover the cases when the obstacle has other edges besides.

O. H. Faxén, Sweden

1652. Moreau, J.-J., Vortex theory of wings in stationary régime (in French), *C. R. Acad. Sci. Paris* **234,** 14, 695–697, Oct. 1952.

1653. Tatsumi, T., Stability of the laminar inlet-flow prior to the formation of Poiseuille regime. I, II, *J. phys. Soc. Japan* **7,** 5, 489–502, Sept./Oct. 1952.

Velocity distribution in the axisymmetric laminar inlet flow through a circular tube is obtained under the assumption of "almost similarity" of velocity profiles. Theoretical velocity distributions obtained agree fairly well with the experimental one in a rather limited region near the tube entrance where the approximation is valid.

A stability analysis of this inlet-flow is made, and it is found that there exists a stability limit whose minimum critical Reynolds number is 9700 at a point 17 times the tube radius downstream from the entrance. This, then, indicates a possibility of instability in the flow before it becomes fully developed and, hence, clarifies the paradox that stability theory predicts stable pipe flow (based on fully developed profile) and experiments show transition.

S. Ostrach, USA

1654. Itō, H., Theory of laminar flows through curved pipes of elliptic and rectangular cross sections, *Rep. Inst. high Speed Mech., Tôhoku Univ.* **1,** 1–16, 1951.

The incompressible laminar viscous flow through pipes whose axes are curved in circular forms and whose cross sections are rectangular and elliptic is studied theoretically. The solutions are expressed in power series of a parameter $K = (Va/\nu)^2(a/R)$, where V is a representative velocity in the direction of the pipe axis, a a characteristic dimension of the pipe (e.g., the radius), R the radius of curvature of the pipe axis, and ν is the kinematic viscosity coefficient. The solutions found for curved pipes of rectangular cross section are applicable if $K \leq 600$, and for the elliptic cross sections if $K \leq 40$. The solutions obtained yielded the helical motion of the fluid through the curved pipes.

More details on the methods of obtaining the specific solutions would have increased the clarity of the paper.

S. Ostrach, USA

1655. Taylor, Sir Geoffrey, Analysis of the swimming of long and narrow animals, *Proc. roy. Soc. Lond.* (*A*) **214,** 1117, 158–183, Aug. 1952.

Author studies the swimming of long and narrow animals by considering the force exerted by a flexible cylinder immersed in water when waves of bending of constant amplitude travel down it at constant speed. He assumes that the force of each element of the cylinder is the same as that which would be determined as acting on an element of a long cylinder moving at the same speed and inclination to the direction of motion. The aerodynamic formulas are first generalized to make them applicable on a wide range of speed and diameter. Connection is established for a smooth cylinder between B/λ, V/U and R_1 (R_1 is the Reynolds number; V the velocity of the cylinder; U the velocity of the wave; B and λ are the amplitude and the wave length). Results of calculation are compared with photographs of a swimming snake and a leech. Rough cylinders are also considered, and the force is studied for a wave of bending which is propagated forward instead of backward (method of propulsion of a marine worm).

L. J. Tison, Belgium

1656. Ichiye, T., On the surface wave in a current, *Oceanogr. Mag.* **3,** 1, 23–26, Mar. 1951.

Using a perturbation method suggested by Thompson [AMR **4,** Rev. 1469], the problem of surface waves propagating on a cur-

rent of varying velocity is treated. Author concludes that, for a wave moving in the same direction as the current, the amplitude increases as the wave propagates into a region of smaller current velocity and conversely for a wave moving against the current. The paper contains several typographical errors and must be read in conjunction with Thompson's work, since the latter's notations are employed without being redefined. The date of Thompson's article is incorrectly given as 1950 instead of 1949.

L. Talbot, USA

1657. Lavrentiev, M., On the exact theory of long waves (Ukranian, with Russian and French summaries), *Zbirnik Prac' Inst. Mat., Akad. Nauk Ukrain. RSR* no. 8, 13–69, 1947.

Consider two-dimensional steady irrotational motion of a heavy incompressible ideal fluid in a channel. Let $y = y_0(x)$ be the equation of the bottom of the channel, and $y = y(x)$ the equation of the free surface. Let h denote the rate of discharge of the fluid per unit width. Let $f(z) = \varphi + i\psi = \zeta$ be the complex potential mapping the strip $y_0(x) \leqq y \leqq y(x)$ in the z-plane onto the strip $0 \leqq \psi \leqq h$ in the ζ-plane. A fundamental problem in the theory of surface waves is to find the class of curves $y(x)$ such that

$$|f'(z)|^2 + 2gy - B = 0 \text{ for } y = y(x)$$

where g is the acceleration of gravity and B is some constant. Levi-Cività and A. I. Nekrasov independently proved the existence of periodic solutions to this problem under certain restrictions. In this paper, author establishes the existence of periodic solutions over a periodic bottom for sufficiently large period, and, in addition, obtains as a limiting case the existence of a solitary wave over a flat bottom. The proof, developed in a long series of lemmas, employs the variational methods in conformal mapping developed by the author and depends in particular on his earlier paper on jets [*Mat. Sbornik N.S.* 4(46), 391–458, 1938].

Misprints are so numerous and frequently of such a confusing nature that trying to follow the details of many of the proofs is (to the reviewer) a frustrating experience. In addition, the equations are not always dimensionally consistent so that the hydrodynamic significance of some of the restrictions is not always clear; however, the preliminary announcement of these results [*C. R. (Dokladi) Acad. Sci. URSS (N.S.)* 41, 275–277, 1943] provides some of the necessary background. The importance of the results would seem to have merited more careful exposition and printing (as well as publication in a more widely read journal and language).

J. V. Wehausen, USA

1658. Sekerzh-Zen'kovich, Ya. I., On the three-dimensional problem of standing waves of finite amplitude on the surface of a heavy liquid (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* 86, 1, 35–38, Sept. 1952.

Problem considered corresponds to one reported on by Penney and Price [AMR 6, Rev. 38]. Using Lagrangian method, an expression of surface elevation to the second is obtained. Author indicates that wave motion considered has a velocity potential.

J. K. Lunde, Norway

Compressible Flow, Gas Dynamics

(See also Revs. 1463, 1676, 1679, 1682, 1689, 1691, 1693, 1697, 1702, 1705, 1707, 1708, 1743, 1744)

1659. Truitt, R. W., A new expression for the pressure coefficient for two-dimensional supersonic flow, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 243–251, 1952. $6.

Shock-wave angles, measured from free-stream direction, are approximated by Mach angle *downstream* of shock. Method is used for both shocks and expansions, and the discussion includes the case of a free-stream Mach number of unity.

N. H. Johannesen, England

1660. Eschborn, R. J., Supersonic flow with whirl and vorticity in axisymmetric channels, *NACA TN* 2768, 41 pp., Aug. 1952.

The axially symmetric supersonic steady flow is treated for a nonviscous fluid flowing with whirl component between two arbitrary coaxial surfaces of revolution. The equations that describe this motion are expressed in characteristic coordinates, and in this form are used to determine the meridional (axial-radial) velocities for arbitrary distributions of the tangential velocity components.

Solution of the supersonic characteristic equations is investigated for arbitrary axisymmetric flow fields with and without vorticity. This solution includes cases in which the channel shape and the inlet velocity distribution are prescribed. Also included are cases in which one of the channel surfaces, the desired velocities on that surface (within certain limitations), and the inlet velocity distribution are prescribed.

From author's summary by A. H. Shapiro, USA

1661. Lukasiewicz, J., and Royle, J. K., Boundary-layer and wake investigation in supersonic flow, *Aero. Res. Counc. Lond. Rep. Mem.* 2613, 22 pp., Oct. 1948, published 1952.

The report describes the results of traverses of the boundary layer and wake encountered in a small supersonic tunnel at a Mach number of 2.5. The tunnel was arranged with two throats in parallel formed by two shaped walls enclosing a shaped central element. Both the laminar and turbulent boundary layers were encountered and compared with existing experimental and theoretical results. The frictional drag of the central element as deduced from the wake traverses is in close agreement with that calculated from considerations of laminar boundary-layer growth over the surface of the element. The tests also provide information relating to the design of nozzle profiles, particularly at the point of inflection, where the changes of pressure gradient may have a serious effect on the boundary layer and on the velocity distribution.

From authors' summary

1662. Leslie, D. C. M., Supersonic theory of downwash fields, *Quart. J. Mech. appl. Math.* 5, part 3, 292–300, Sept. 1952.

Author reviews the extended conical-flow method of Lagerström and Graham, and the line vortex method of Mirels and Haefeli for computing supersonic downwash fields.

By integrating by parts (after the fashion of Ward) Hadamard's solution to the linearized potential equation (expressed as the finite part of an infinite integral), the potential function is obtained in the form

$$\varphi(r) = \frac{1}{\pi}\int\int \frac{\partial\varphi}{\partial x'}\,\frac{z(x-x')}{\{(y-y')^2+z^2\}\,R}\,dx'dy'$$

where

$$R = [(x-x')^2 - \beta^2\{(y-y')^2+z^2\}]^{1/2}$$

To prevent the occurrence of a divergent integral when this expression is differentiated with respect to z, the author integrates it again by parts, obtaining as a solution

$$\varphi(r) = -\frac{1}{\pi}\int\int \frac{\partial^2\varphi}{\partial x'\,\partial y'}\tan^{-1}\left\{\frac{zR}{(x-x')(y-y')}\right\}dx'dy'$$

which can be differentiated readily, yielding a finite integral expression for the downwash

$$w = \frac{\partial \varphi}{\partial z} = -\frac{1}{\pi} \int\int \frac{\partial^2 \varphi}{\partial x' \partial y'} K(x')\, dx' dy'$$

where

$$K(x) = (x - x')(y - y')(R^2 - \beta^2 z^2)/ [R\{(x - x')^2 - \beta^2 z^2\}\{(y - y')^2 + z^2\}]$$

and the integration is over that part of the wing which lies within the forecone of r. The author notes equivalence between this formula and those of Robinson and Hunter-Tod.

Author proceeds to show by direct substitution that, if conical flow is assumed, the above expression for downwash reduces to Lagerström and Graham's formula, while a similar formula to that of Mirel and Haefeli's can be derived by assuming the wing to be replaced by a lifting line along the line $x' = 0$.

Reviewer believes that the value of this paper lies in its generality as emphasized by the fact that its resultant formulas can be used to determine directly the flow field behind wings in supersonic free streams, either by introduction of the somewhat physically nebulous compressible line vortex, or by application of the Busemann conical-flow concept. Further, it provides some insight into the approximations of each method, which the reviewer feels is significant. G. V. Bull, Canada

1663. Shen, S.-F., An estimate of viscosity effect on the hypersonic flow over an insulated wedge, *J. Math. Phys.* **31, 3,** 192–205, Oct. 1952.

Author uses the usual compressible boundary-layer equations whose validity for hypersonic flow he established earlier [*J. aero. Sci.* 19, 7, 500–501, July 1952] for $\delta/L = 0\ (1/M)$; δ is boundary-layer thickness, L length of wedge surface, M free-stream Mach number. The hypersonic parameter $K = M\beta$, where β = wedge semi-angle, is then of order unity. The shock wave is assumed to be the outer boundary of the layer, and the oblique shock conditions connect the free-stream flow variables to those in the layer.

The solution is found in the form of a series of the case of Prandtl no. = 1 with no heat transfer and a linear velocity profile, but for all values of K. The distance over which the boundary layer is in contact with the shock wave is calculated. The case of the flat plate is also worked out, and the extension to a heat-conducting surface with general Prandtl number is discussed briefly. Some minor typographical errors are present.
R. E. Street, USA

1664. White, D. R., An experimental survey of the Mach reflection of shock waves, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 253–262, 1952. $6.

An interferometric survey of the Mach reflection of shock waves has been carried out, symmetrical wedges of half-angles $\epsilon = 5.7°$, 11.5°, 22°, 30°, and 38° being used in the shock tube and the entire density field determined. The pressure along the wedge has been determined from the density and is reported for eleven shock strengths from $\xi = 0.10$ to $\xi = 0.90$ at each wedge angle. Smith's observation of the persistence of regular reflection beyond the theoretically limiting extreme shock strength has been verified by an independent method. The shape, and hence strength of the entire reflected shock is given for three angles and a number of strengths. New phenomena in the reflection process have been observed at the larger angles for the strongest shocks, the slipstream curling under itself at the wedge and being joined to the reflected shock by a new shock, the latter interaction giving rise to a second slipstream. From author's summary

1665. Fettis, H. E., Reciprocal relations in the theory of unsteady flow over thin airfoil sections, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 145–154, 1952. $6.

From the integral equation of two-dimensional, nonstationary, compressible airfoil theory, reverse-flow theorems are derived which are in agreement with those of A. H. Flax [AMR 5, Rev. 2666]. They are applied to investigate the accuracy of existing aerodynamic coefficients [see also Fettis, *J. aero. Sci.* 19, 5, 353, May 1952]. H. Merbt, Sweden

1666. Germain, P., and Bader, R., On some problems relating to the Tricomi equation of mixed type (in French), *ONERA Publ.* no. 54, 57 pp., 1952.

This paper studies certain mathematical problems which arise in connection with equations of mixed type, such as govern transonic flow. The simplest such equation, which is sometimes used as an approximation for transonic flow, is the Tricomi equation, which is the subject of the paper.

In chapter 1, families of solutions of the Tricomi equation are found, among which are the Riemann function and the family of fundamental solutions used for purely elliptic problems. In chapter 2, explicit solutions of the Tricomi equation are found for particular formulations of the initial conditions (a) in the hyperbolic, (b) in the elliptic domain, some part of the initial conditions being specified on the parabolic line. Chapter 3 contains a demonstration of the existence of the solution of Tricomi's problem of mixed type when the subject of the equation (e.g., the stream function) is given on a characteristic together with a curve in the elliptic domain which begins and ends on the parabolic line and is only required to satisfy certain conditions of regularity. D. C. Pack, England

1667. Liepmann, H. W., and Lapin, E., Summary of characteristics methods for steady state supersonic flows, *Douglas Aircr. Co., Rep.* SM-13343, 33 pp., 1949.

Characteristics method in the case of two independent variables is reviewed briefly. Application is made to two-dimensional and axially symmetric supersonic flow without and with vorticity. There are no new results, but paper presents a uniform derivation of the usual formalism (Sauer, Guderley, etc.). Paper contains some interesting remarks on practical questions—computation time and solution accuracy as dependent upon lattice size, comparison with slender-body theory. These results are based only on numerical examples and not on theoretical error evaluation.
R. Sauer, Germany

1668. Gunkel, R. J., Downwash and sidewash behind a thin delta wing in compressible subsonic flow, *Douglas Aircr. Co., Rep.* SM-13326, 20 pp., 1948.

Formulas for downwash and sidewash are given in closed form and compared to similar formulas of Lagerström, P. A., and Graham, M. E. [title source, no. SM-13007, 1947], treating the same problem for supersonic flow. Spanwise variation of downwash and sidewash functions is given in graphical form.
From author's summary by F. Keune, Sweden

1669. Van Dyke, M. D., Impulsive motion of an infinite plate in a viscous compressible fluid, *ZAMP* **3,** 5, 343–353, Sept. 1952.

In the present paper, the boundary-layer solution is improved in a systematic manner. The procedure involves alternately iterating upon the boundary-layer solution in the boundary layer and upon the acoustic solution in the outer flow field. The two solutions are matched at the outer edge of the boundary layer by comparing their asymptotic expansions. For simplicity, the

assumptions are made of Prandtl number equal to 1, linear variation of viscosity with enthalpy, and an insulated plate. The results complement Howarth's solution [AMR **4**, Rev. 4537], and agree with it in the region of common validity. The third approximation is carried out in detail. Interaction between the boundary layer and the outer flow field is found to reduce the skin friction.

From author's summary by R. C. Roberts, USA

1670. Lee, J. D., The influence of high adverse pressure gradients on boundary layers in supersonic flow, *Univ. Toronto Inst. Aerophys. Rep.* 21, 29 pp., 46 figs., Oct. 1952.

Paper reviews theoretical work as background for experimental program. Adverse pressure gradients are developed by a cone-cylinder model placed in a supersonic wind tunnel at Mach numbers of 1.56, 2.48, and 3.00. Optical methods of observation, i.e., schlieren and interferometer systems, are employed so as to avoid extraneous disturbances of the boundary layer. Most of the work done is concerned with laminar boundary layers, relations being given for the distance upstream which is influenced by the corner and its pressure gradient. The separation angle is also determined. M. J. Thompson, USA

1671. Saunders, O. A., and Calder, P. H., Heat transfer in a nozzle at supersonic speeds, *Engineering* **174,** 4518, 281–284, Aug. 1952.

Paper describes experimental investigations of heat transfer in divergent part of a convergent-divergent nozzle. This is important in connection with cooling of walls of combustion chambers in rockets and the like. The apparatus used consists of a burner of special design, which raises the temperature of gases to about 800 C, and a subsequent nozzle in the divergent part of which cooling of walls is applied. Rate of heat transfer was found by measuring the temperature gradient in the nozzle wall at various places along the nozzle. Results compare well with theory, if a turbulent boundary layer is assumed starting from the throat of the nozzle. Range of Reynolds number, based on distance from throat, was about 8.10^4 to 1.10^6. Authors compare this with a value of 8.10^5 for the critical Re number, as found by Johnson and Monaghan [AMR 5, Rev. 1813] in experiments on a flat plate. Reviewer thinks the apparent discrepancy could be explained by the high intensity of turbulence in main stream in authors' experiments, due to a burner being ahead of the nozzle. Dryden [*NACA Rep.* 562, 1936] found $Re_{crit} = 1.10^5$ on a flat plate with a 3% intensity of turbulence in the main stream; similar conditions might be expected behind a burner. H. Schuh, Sweden

1672. Adamov, G. A., Flow of real gases in vertical pipes (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **84,** 3, 457–460, May 1952.

Equations for vertical flow of real gas are integrated, assuming isothermal process, constant pipe diameter, and constant Reynolds number and friction coefficient. Deviation from perfect gas law, important for hydrocarbon gases under high pressure, is accounted for by equation of state $p = (\rho gRT)/(1 + kp)$, k an empirical constant, which is good approximation up to 100 or 120 atmospheres. Resulting implicit equation for pressure can be solved by successive approximations.

M. D. Van Dyke, USA

1673. Phythian, J. E., Some unsteady motions of a slender body through an inviscid gas, *Quart. J. Mech. appl. Math.* **5,** part 3, 301–317, Sept. 1952.

Report represents an extension of Ward's slender-body analysis [AMR **3,** Rev. 529] to include variations in time for forward velocity and angle of incidence. Method of sources is used to study, first, bodies of revolution and, second, bodies of general cross section. Explicit expressions are given for drag, lateral forces, and pitching moment. Author concludes that extra aerodynamic force components produced by linear and angular acceleration are small compared with the corresponding aerodynamic force components in steady motion, provided changes in linear and angular velocity, in the time the body takes to travel its own length, are small compared with the actual linear and angular velocities, respectively. M. A. Heaslet, USA

1674. Abdurahiman, P. V., Two-dimensional compressible flow past a solid body symmetrically placed in a channel, *Aero. Res. Counc. Lond. Rep. Mem.* 2443, 6 pp., Oct. 1947, published 1952.

The Goldstein and Lighthill method [*Phil. Mag.* **35,** 7, p. 549, Aug. 1944] for finding compressibility effect on potential flow past a solid body in a channel is used to determine the blockage factor for title configuration as a function of Mach number. Blockage factors are given in tabular form for various ratios of channel width to body thickness. S. Lampert, USA

Turbulence, Boundary Layer, etc.

(See also Rev. 1670)

1675. Theodorsen, T., Mechanism of turbulence, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 1–18, 1952. $6.

According to author, turbulent flows are characterized by similar three-dimensional vortex pattern which, in the case of pipes and boundary layer, consists of horseshoe vortexes inclined to the mean flow. There is a continuous generation and decay of these vortexes. He says that the von Kármán similarity law follows from this assumed similarity. Vortex structure is used to explain qualitatively some characteristics of turbulent flows, such as skewness (presumably in the probability density of v). Author emphasizes the well-known fact that in two-dimensional flows, vorticity can only be generated at the boundary, while in the three-dimensional case it is also generated in the interior by stretching of vortex lines. He says that two-dimensional parallel flows are always stable to two-dimensional disturbances because vortex-stretching is absent. Mathematical proof supporting his claim is based on questionable assumption of absolutely steady mean flow and a stiff pressure gradient. Any possible increase in perturbation energy must come from either the mean motion or the pressure gradient, i.e., either the mean flow should slow down or the pressure gradient should increase to provide the increase in perturbation energy. Also, it has been proved, without linearizing the equations, that some two-dimensional parallel flows are unstable to particular two-dimensional disturbance [e.g., Lorentz, "Abh. u. Theor. Phys." p. 43]. M. S. Uberoi, USA

1676. Crocco, L., and Lees, L., A mixing theory for the interaction between dissipative flows and nearly isentropic streams, *J. aero. Sci.* **19,** 10, 649–676, Oct. 1952.

Authors use mean values in the dissipative part of the flow near the surface of a body or in its wake in an analogy to the von Kármán momentum equation. Between the mean velocity and mean temperature there exists a relation which, according to present experience, seems to be of general validity. Together with the assumption of a constant mixing coefficient, this gives a single nonlinear differential equation of motion which may be applied to problems of boundary layer, separated and reattaching flow, wake flow behind blunt-based bodies, and boundary-layer shock-wave interaction. In this equation a "critical point" exists for

supersonic wake flow and, under certain conditions, for supersonic flows directed toward a solid surface. This critical point acts like the throat of a nozzle. In the case of separated and reattaching flows, or wake flows, equation is reduced to a simplified form. The theory is applied to these cases, especially to the determination of the base pressure for a supersonic airfoil with a blunt trailing edge. A. Betz, Germany

1677. **Inoue, E., Some remarks on the Lagrangian correlation coefficient of turbulent diffusion in a wind tunnel flow,** *J. Phys. Soc. Japan* **7,** 5, 503–507, Sept./Oct. 1952.

The problems associated with the turbulent diffusion of non-dynamical particles in a wind-tunnel flow, including the decay phenomena, are discussed. Expressions are derived for the Lagrangian correlation coefficients in terms of the lifetime of the smallest and largest eddies in the flow, the kinematic viscosity, and the rate of dissipation of the turbulent energy. The discussion includes the variation of such parameters as the Lagrangian smallest eddy with the turbulence decay in a wind-tunnel flow downstream of a gauze. G. M. Lilley, England

1678. **Inoue, E., Influences of the length of hot-wire anemometer on the measurement of turbulent flow,** *J. phys. Soc. Japan* **7,** 4, 508–510, Sept./Oct. 1952.

For purposes of evaluating measurements of atmospheric turbulence, author uses results of the statistical theory of turbulence excerpted from the writings of G. I. Taylor, G. K. Batchelor, and from Kolmogoroff's similarity hypothesis. He investigates theoretically the effect of length of the hot-wire filament, if slightly larger than the size of the "smallest eddy" and sufficiently less than the largest wave length, upon the curvature of the spatial correlation curve (in the plane of the wire) at its origin, and upon the measured wave lengths. Disregarding errors in readings of the intensity of turbulence, he finds that the measured smallest wave length increases as the 2/3 power of the filament length. J. R. Weske, USA

1679. **Rott, N., and Crabtree, L. F., Simplified laminar boundary-layer calculations for bodies of revolution and for yawed wings,** *J. aero. Sci.* **19,** 8, 553–565, Aug. 1952.

See AMR **5,** Rev. 2902.

1680. **Krzywoblocki, M. Z. E., On locally isotropic turbulence in compressible fluids,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 35–48, 1952. $6.

Kolmogoroff's theory of locally isotropic turbulence is extended in the present paper to the case of compressible fluid flow. Four equations are considered—the equations of motion, continuity, state, and energy. Kolmogoroff's similarity hypotheses are generalized to cover the heat-conduction and compressibility phenomena. From author's summary

1681. **Görtler, H., On the laminar boundary layer of yawed cylinders. Part I** (in German), *Arch. Math.* **3,** 216–231, 1952.

Speed outside the boundary layer is, as usual, split up into two components, one normal and the other parallel to axis of cylinder; flow due to first component is identical with that on an unyawed cylinder, which is well known, and therefore second component only need be calculated. Method of Blasius [see, e.g., Goldstein, "Modern development in fluid dynamics," Oxford, 1938], using an expansion in power series of speed outside the boundary layer, is applied to calculating axial component of boundary-layer flow. Symmetrical flow around cylinder and four terms in the power series are assumed. Author calculates the resulting seven universal functions and their first derivates. Second part of paper, in which author promises applications, must be awaited before an opinion can be formed whether four terms in the power series are sufficient to calculate axial component of boundary layer on slender cylinders, like airfoils, up to the separation point.

H. Schuh, Sweden

1682. **Brown, W. B., and Livingood, N. B., Solutions of laminar-boundary-layer equations which result in specific-weight-flow profiles locally exceeding free-stream values,** *NACA TN* 2800, 36 pp., Sept. 1952.

Authors reconsider former approximate numerical results [AMR **5,** Rev. 956] for constant wall temperature and small Mach numbers when large temperature changes in the boundary layer and large pressure changes in the main stream occur simultaneously. New numerical solutions for such cases, which satisfy the free-stream conditions more accurately, result in specific weight flows which exceed the free-stream values.

H. Görtler, Germany

1683. **Pabst, E., Criterion for the separation of the boundary layer in presence of compression shocks** (in Spanish), *Comun. Inform. Escuela Super. Aerotec., Cordoba,* C4, 11 pp., 7 figs., Apr. 1952.

Analysis is presented for pressure rise across a weak normal shock that will just separate a laminar or a turbulent boundary layer. This pressure rise is interpreted as that which will cause final boundary-layer thickness to tend toward infinity in an approximate application of the von Kármán integral momentum equation neglecting wall friction. Main calculated results are equivalent to: laminar, $10^3 \leq Re \leq 10^5$, $\Delta p/q_1 = 5.7\ Re^{-0.42}$; turbulent, $10^6 \leq Re \leq 10^8$, $\Delta p/q_1 = 0.75\ Re^{-0.062}$. Reviewer believes these results are not valid consequences of basic assumptions because of analytical and arithmetical errors; correction factors ranging from 2/3 to 3 appear to be required. Agreement with Stewartson's $Re^{-3/5}$ law for laminar layers [AMR **5,** Rev. 785] is considered fortuitous. H. S. Ribner, USA

1684. **Horton, E. A., Loftin, L. K., Jr., Racisz, S. F., and Quinn, J. H., Jr., Analysis of the effects of boundary-layer control on the take-off and power-off landing performance characteristics of a liaison type of airplane,** *NACA Rep.* 1057, 31 pp., 1951.

See AMR **1,** Rev. 1156, and **4,** Rev. 2172.

Aerodynamics of Flight; Wind Forces

(See also Revs. 1527, 1534, 1572, 1652, 1662, 1665, 1668, 1684, 1695, 1696, 1697, 1762)

1685. **Schade, R. O., and Hassell, J. L., Jr., The effects on dynamic lateral stability and control of large artificial variations in the rotary stability derivatives,** *NACA TN* 2781, 56 pp., Oct. 1952.

See AMR **5,** Rev. 2690.

1686. **Miele, A., Graphs for rapid calculation of flights with accelerated climb** (in Spanish), *Cienc. y Técn.* **119,** 602, 59–67, Aug. 1952.

A factor dependent upon acceleration is introduced for correcting "rate-of-climb" values computed from equations of steady flight. Formulas for this correction factor are derived, under various approximate assumptions, for the climb with minimum time of turbojet aircraft, rocket-powered aircraft, and climb with constant dynamic pressure. L. Landweber, USA

1687. Andrew, G. M., End correction for flight-tested frequency response obtained by Laplace transformation, *J. aero. Sci.* **19,** 8, 569–570, Aug. 1952.

Note in Readers' Forum.

1688. Prosciutto, A., On the characteristic properties of special types of airfoil cascades generated by means of conformal transformations (in Italian), *Mem. Accad. Sci. Ist. Bologna, Cl. Sci. Fis.* (10) **8** (1950–1951), 75–81, 1952.

Author obtains a class of conformal representations of the circle onto a cascade of curved airfoils, usually without thickness, and discusses the use of these to obtain aerodynamic properties of such cascades. M. J. Lighthill, England

1689. Yeh, H., The development of cascade profiles for high subsonic potential flows, *J. aero. Sci.* **19,** 9, 630–638, Sept. 1952.

A design method is presented for high subsonic plane potential cascades of moderate camber with prescribed inlet and exit flow conditions and approximately prescribed solidity, which is based upon Lin's conformal transformation and von Kármán-Tsien's linear adiabatic state approximation. It is shown that, with proper selection of that approximation, relative errors as compared to an isentropic gas at same velocity are less than 2% for a Mach number range 0.4–0.9. Known fact is confirmed that, within this range, the influence of inlet Mach number value on that of exit flow deviation from geometrical cascade-exit direction is negligible.

When author asserts that "only by comparison with a known two-dimensional potential solution can one evaluate the magnitude of the viscous and three-dimensional effects of an actual cascade," this holds true only for a comparison with an actual *plane* cascade. But an actual cascade is, in most cases, a circular blade arrangement, and actual tendency to use it to produce rotational gyratory flow patterns limits seriously the worth of each comparison with a plane potential-flow solution.

P. Schwaar, Switzerland

1690. Sissingh, G. J., The effect of induced velocity variation on helicopter rotor damping in pitch or roll, *Aero. Res. Counc. Lond. curr. Pap.* no. 101, 12 pp., 4 figs., Nov. 1951, published 1952.

In his theory of aerodynamic rotor damping [AMR **4,** Rev. 2189], Amer assumed uniform induced velocity through the disk. In present work, variation of the induced velocity is considered. Thus extended, theory shows good agreement with tests, and author concludes that the amount of damping of rotor, with non-offset flapping hinges, depends not only on the ratio of collective pitch angle to thrust coefficient divided by solidity $\Theta/(C_T/\sigma)$, as found by Amer, but also on the value of tip-speed ratio times rotor angle of attack divided by collective pitch angle $\mu\alpha/\Theta$. Positive values of $\mu\alpha/\Theta$ (autorotation) increase damping; negative (helicopter regimes of flight) decrease. Loss of damping may manifest itself in helicopter flights at high μ's as well as in forward climbs. W. Z. Stepniewski, USA

1691. Neumark, S., Velocity distribution on straight and sweptback wings of small thickness and infinite aspect ratio at zero incidence, *Aero. Res. Counc. Lond. Rep. Mem.* 2713, 40 pp., May 1947, published 1952.

This report is the first of a series enabling the velocity distribution (and hence the critical Mach number) to be determined for a sweptback wing.

An approximate method, using source-sink distributions, is given for determining the velocity distribution for (1) a straight wing of infinite aspect ratio, (2) an infinite sheared wing, and (3) an infinite sweptback wing at zero incidence. The airfoil sections are assumed to be thin and symmetrical with respect to the chord. The report gives a critical examination of this method, showing that, for airfoil sections with pointed leading and trailing edges, the method is accurate over almost the whole profile, enabling the supervelocity to be determined accurately. The method may fail partly in the case of a profile with a rounded leading edge where the maximum supervelocity occurs near to it. A number of examples of the velocity distribution in two-dimensional flow are given, including that for biconvex profiles, elliptic profiles, and modified symmetric profiles with rounded edges. The method is easily extended to an infinite sheared wing, the component of velocity perpendicular to the span being obtained as in the two-dimensional flow of an unsheared wing; it is shown that the same results can be obtained directly by applying the method of sources and sinks, using a system of oblique source filaments parallel to the wing span.

By considering kinked source filaments, the method is extended to deal with infinite sweptback wings. General curves are given for the velocity distribution for sweptback wings with biconvex parabolic sections, and a simple formula is given for the supervelocity at the kink (center) section. This differs from that given by Ludwieg [British Reports and Translations 84], and the error in Ludwieg's work is discussed in detail.

Isobars are drawn for a sweptback wing with a parabolic section. It is shown that the maximum supervelocity occurs at the kink and is always located further aft (and is usually greater) than for an infinite sheared wing. The maximum supervelocity decreases with increasing sweepback. A. W. Babister, Scotland

1692. Graham, Martha E., Some linearized computations of supersonic wing-tail interference, *Douglas Aircr. Co., Rep.* SM-13430, 54 pp., 1948.

The lift and center of pressure are given for delta tails behind delta wings; wing and tail are at same angles of attack with the tail pictured as sweeping downward on the end of a rod as the wing angle is increased. Interference effects of a body are not considered. Charts give the lift and center of pressure on the tail as the angle of attack; Mach number, ratio of tail area to wing area, distance between wing and tail are varied. Several delta planforms are considered. Comparison is made of the effect of assuming the downwash to be given by a vortex sheet or by rolled-up vortexes. Linearized theory is used to predict the tail forces in the downwash field, further approximation being made in the root region of narrow delta wings.

Since this early report, more general results have become available. Vortex downwash distributions are studied by Sacks [AMR **5,** Rev. 2108]; while Heaslet and Spreiter [AMR **6,** Rev. 988] discuss applications of linear theory to the nonuniform flow problem. L. H. Schindel, USA

1693. Beane, Beverly, Influence functions for computing lift and rolling moment of a twisted narrow delta wing, *Douglas Aircr. Co., Rep.* SM-14532, 8 pp., Oct. 1952.

According to the aerodynamic reciprocity concept, the total lift and rolling moment on any wing planform in a spanwise-varying downwash field may be written as the integral over the span of the product of the local angle of attack and an influence function which, for the lift case, is the span-loading for the same planform at constant angle of attack in reverse flow and, for the rolling case, is the span-loading for the same planform rolling with constant angular velocity in reverse flow. In this note, approximate solutions are developed for the span-loadings at supersonic speeds for a flat reverse delta wing with subsonic edges. The slender-wing theory is used for the span-loading inboard of the

spanwise station at which the tip Mach cones first intersect the trailing edge. Outboard of this station, exact loadings are known. The loadings are checked against some exact solutions for the forward delta wing and are found to be good. They are useful in reducing the complexity of many problems involving the calculations of lift or rolling moment on forward delta wings in nonuniform flow fields. T. Gullstrand, Sweden

1694. Goin, K. L., Equations and charts for the rapid estimation of hinge-moment and effectiveness parameters for trailing-edge controls having leading and trailing edges swept ahead of the Mach lines, *NACA Rep.* 1041, 71 pp., 1951.

See AMR **4**, Rev. 3329.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 1569, 1687)

1695. Ashley, H., Dugundji, J., and Nelson, D. O., Two methods for predicting air loads on a wing in accelerated motion, *J. aero. Sci.* **19**, 8, 543–552, Aug. 1952.

The standard method of calculating the take-off performance, assuming steady-state lift and induced drag, underestimates the take-off distance during a short rapidly accelerated take-off. Author uses the results of von Kármán and Sears [title source, **5**, 10, Aug. 1938] to determine the transient lift on a two-dimensional airfoil in terms of the distribution of vorticity in the wake.

The exact solution of these equations is based on the Laplace transformation solution of the resulting integral equation. An approximate iterative method is given for evaluating the two-dimensional lift during a maneuver involving changing forward speed and changing angle of attack.

The method is applied to the case of an airfoil having a sudden change of incidence (Wagner's problem), and there is good agreement after two steps of the iterative solution. The method is also applied to an airfoil moving with velocity proportional to a power of the time. The effect of head wind on the unsteady lift is also discussed, and it is shown that the unsteady effects are equally important in this case.

The method can be applied to determine the growth of the aerodynamic forces due to a horizontal gust.

A. W. Babister, Scotland

1696. Fisher, L. R., and Wolhart, W. D., Some effects of amplitude and frequency on the aerodynamic damping of a model oscillating continuously in yaw, *NACA TN* 2766, 24 pp., Sept. 1952.

An indication of a reduction in damping in yaw appeared as the amplitude of oscillation was reduced through the range of small amplitudes investigated. The decrease of the lateral damping with reduced-frequency parameter at low frequencies of oscillation was slightly greater than the small variation predicted by the finite-span unsteady-lift theory, but not so large as the variation indicated by two-dimensional theory.

From authors' summary

1697. Berndt, S. B., On the theory of slowly oscillating delta wings at supersonic speeds, *Flygtekn. Försöksanst. Medd.* 43, 19 pp., 1952.

It has been noted [AMR **3**, Rev. 1135; **4**, Rev. 787] that the quasi-steady method is incorrect as a first approximation in calculating some stability derivatives (e.g., in pitching motion). Author seeks for limits of its validity using a more complete linearized equation, and expanding the potential into a series of powers of streamwise distance from the apex multiplied by the frequency; an iterative method is brought up, which allows the wing to distort, too.

Quasi-steady approximation is seen to be satisfactory only for oscillations which maintain the chords parallel to the undisturbed flow. Method is applied to a narrow, rigid, triangular wing. G. Moretti, Argentina

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1508, 1517, 1660, 1739)

1698. McCormick, B. W., Jr., The application of an electromagnetic analogy to the determination of induced camber correction for wide-bladed propellers, Heat Transfer Fluid Mech. Inst., Stanford Univ. Press, 111–124, 1952. $4.

The analogy between the magnetic field of a current-carrying wire and the velocity field of an isolated vortex is the basis for an apparatus whereby the cambers of wide-bladed propellers can be corrected from results of lifting-line theory to account for the induced curvature of flow associated with the vortex system of the propeller. The "remainder" vortex system prescribed by the theory of Ginzel and Ludwieg is replaced by an equivalent system of current-carrying wires. Voltages induced in a small probe coil by the associated magnetic field are measured and converted into induced velocities. Calibration of the entire measuring system consisting of the probe coil, amplifier, and electronic voltmeter is accomplished by means of a ring of wire simulating a ring vortex. Measured correction factors agree satisfactorily with calculated values. From author's summary

1699. Söhngen, H., Passage of the potential disturbance through a guide vane ring (in German), *Ing.-Arch.* **20**, 1, 13–18, 1952.

The effect of support struts on the two-dimensional potential flow through a cascade of guide vanes is investigated under the assumption of small gap-cord ratios and vanes of zero thickness; the struts have a symmetrical profile and their spacing is large compared to those of the vanes. The potential problem is solved in terms of Fourier series, and the results indicate an appreciable disturbance upstream of a decelerating cascade due to the struts downstream of it. On the other hand, no disturbance results downstream of an accelerating cascade from the struts located ahead of it. A. Fejer, USA

1700. Hausenblas, H., and Pfleghaar, A., Calculation of flow in a combustion chamber for gas turbines (in German), *Motortech. Z.* **13**, 8, 193–197, Aug. 1952.

Since calculations of flow path for primary combustion and for the mixing process in a gas-turbine combustion chamber are now commonplace, the considerable labor required for such calculations can be greatly reduced by use of charts with dimensionless ratios of the important parameters. Such charts are presented here for pressure ratio, velocity ratio, temperature ratio, and Mach number vs. area ratio for the primary combustion process, and similar charts are given for the mixing process of the secondary cooling air with the hot products of the combustion process. The charts are based on the simple one-dimensional flow model and use the energy, momentum, and continuity equations, as well as the perfect gas relations. Wall friction is neglected in the analysis. J. Kaye, USA

1701. Hamrick, J. T., Ginsburg, A., and Osborn, W. M., Method of analysis for compressible flow through mixed-flow centrifugal impellers of arbitrary design, *NACA Rep.* 1082, 10 pp., 1952.

See AMR **4**, Rev. 1749.

1702. Schwaar, P., Some remarks on the aerothermodynamic calculation of blades in axial turbomachines (in French), *Bull. tech. Suisse Rom.* **78,** 19, 245–251, Sept. 1952.

Knowledge of velocity distribution of fluid leaving stator and rotor blades is necessary for accurate design of blade shape; otherwise, velocity profiles in later stages of multistage machines may differ widely from those on which blade shape is based. Author develops a method of calculation, based on ordinary thermodynamic relations, which takes account of radial distribution of energy (or temperature) and efficiency, and of radial migration of streamlines, but assumes no circumferential variation. Calculation involves iterative process, starting with specified radial variation of tangential velocity component or of fluid exit angle, and may become very laborious for multistage machine. However, first calculation often shows effect of radial migration to be negligible, and process is then much simplified. Author states that turbojet turbines have not given expected performance, and even today have lower polytropic efficiency than compressors, presumably because of radial variations not allowed for in design; but to reviewer this seems doubtful.

C. W. Smith, USA

1703. Meyer, R., Some new results concerning the regulation of turbines and of hydraulic installations in general (in French), *Houille blanche* **7,** 4, 567–590, Aug./Sept. 1952.

Author shows that, by substitution of $p = x - c$ into the characteristic equation of the form $a_n p^n + a_{n-1} p^{n-1} + \ldots + a_0 = 0$, and using Hurwitz's conditions on the equation $f(x - c) = g(x) = 0$ thus obtained, it is possible to plot the contours of the damping-hill of the regulating system. The seat of the hill is the boundary of stability domain, and the top defines an optimum governor for the given installation.

The method is applied to hydraulic systems, especially to installations with surge tanks. M. Nechleba, Czechoslovakia

1704. Fox, N. L., The pumping characteristics of long mixing section jet pumps, *Douglas Aircr. Co., Rep.* SM-14385, 40 pp., May 1952.

Two theoretical analyses are presented for the pumping characteristics of a jet pump, both of which assume complete mixing in a constant-area mixing section which is not choked, and neglect friction. The first analysis, which considers incompressible fluids, yields a relatively simple equation. The second analysis, which considers compressibility, leads to a more accurate solution, but is tedious for calculation.

A comparison of the theoretical analyses and experimental data is then made and correction factors derived which, when applied to the incompressible analysis, permit the determination of jet-pump characteristics with sufficient accuracy for most engineering applications. G. C. Quigg, Australia

1705. Wu, C.-H., Brown, C. A., and Costilow, Eleanor L., Analysis of flow in a subsonic mixed-flow impeller, *NACA TN* 2749, 38 pp., Aug. 1952.

A method, recently developed for determining the steady flow of a nonviscous compressible fluid along a relative stream surface extending from hub to casing between two adjacent blades in a turbomachine, is applied to investigate the through flow of air in an experimental mixed-flow impeller of high solidity. A detailed analysis is made of both incompressible and compressible flow through the impeller, and contour plots of the stream function, velocity components, total enthalpy, static pressure, and Mach number are presented and discussed. The trends of flow variations in the impeller for the incompressible and compressible solutions are quite similar. The trend in the variation of static pressure along the casing obtained in the compressible solution compares very well with the experimental data obtained under the same operating condition.

From authors' summary by J. F. Manildi, USA

1706. Gazarin, A., Graphical treatment of compressible and incompressible flow through the stages of turbomachines (in German), Thesis, ETH, Zürich, Prom. no. 2059, 89 pp., 20 figs., 1951.

The general theory of flow through axial stages of turbomachines with blades of large radial dimensions was treated by W. Traupel (1942) with the following assumptions: Circumferential distances between blades are infinitely small (rotationally symmetric flow); no friction, but circulation around the blades is present; flow is incompressible. In more detail, the same flow type was calculated independently and measured by Eckert and Korbacher (1943). They calculated the state of the flowing medium including its velocities in planes normal to the axis of rotation ahead of the stationary blades, between the stationary and rotating blades, and behind the rotating blades, with the additional assumption that the curvature of the streamlines in the meridional plane can be considered as small. These calculations were applied to blades which are straight along the blade length or arbitrarily twisted. Traupel (1950) [see AMR **4,** Rev. 3030] extended them to include compressibility. In the reviewed paper, Gazarin develops a procedure to solve graphically the system of equations which describe the flow under the above conditions with the help of isentropic diagrams introduced by Quiby. He treats the following stages in detail: (1) Constant mass flow per unit area in the planes between and behind stage; (2) untwisted blades; (3) blades twisted so as to produce solid vortex flow (absolute circumferential velocities proportional to distance from axis of rotation); (4) flow with reaction constant along blade length. Calculations are extended to stages with conical walls. The influence of viscosity on the actual flow through stages is discussed as far as secondary flow, radial flow of the boundary layers, flow through clearances, and influence of blade geometry are concerned. E. R. G. Eckert, USA

Flow and Flight Test Techniques

(See also Revs. 1647, 1661, 1677, 1678, 1696, 1698, 1722)

1707. Biles, M. B., and Putnam, J. A., Use of a consolidated porous medium for measurement of flow rate and viscosity of gases at elevated pressures and temperatures, *NACA TN* 2783, 51 pp., Sept. 1952.

With normal laboratory techniques it appears possible to calibrate large porous Alundum filtering thimbles to meter gas with a probable error of 0.1 to 0.2%. The geometry of such elements permits an appreciable range of gas flow rate to be metered with small, accurately controlled, pressure drops. The advantages of such a device warrant its use as a laboratory instrument.

Results of the flow tests have been employed in the determination of the viscosity of air up to approximately 900 psi absolute at the two test temperatures of 75 and 517 F. These data appear to check sufficiently well with other published viscosity data.

From authors' summary

1708. Colombi, C., Fluid dynamics and surface phenomena. Application of motion of surface films to fluid dynamics (in Italian), *Termotecnica* **6,** 9, 375–398, Sept. 1952.

Author discusses principle of the experimental method as well as actual apparatus; describes details of experimental results for rectangular channels with and without bends. He concludes

that experimental technique is developed sufficiently to give qualitative results, but quantitative results are still somewhat uncertain. M. J. Goglia, USA

1709. **Hundstad, R. L., Three-dimensional flow measuring probe,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 521–529, 1952. $6.

Paper deals with the design, development, and operation of a three-dimensional flow measuring probe designed to satisfy the need for a versatile instrument which could be used for fluid-flow studies; especially, flow studies in combustion chambers, compressors, and diffuser sections.

The sensing element of the probe is a sphere attached to a support tube in such a way that the sphere has two degrees of freedom.

Pitch angles of the velocity vector are measured by a particular arrangement of openings on the surface of a sphere. The yaw angle can be determined through the full range of $\pm 180°$ and the pitch angle through a limited range of $\pm 45°$. Static pressure is observed directly from readings of manometers or other pressure-measuring devices connected to the instrument, and dynamic pressure is determined from the observed pressures at the several openings on the surface of the sphere.

From author's summary

1710. **Sterrett, J. R., and Erwin, J. R., Investigation of a diffraction-grating interferometer for use in aerodynamic research,** *NACA TN* 2827, 36 pp., Nov. 1952.

A low-cost interferometer that has a large field of view is described. Instrument, which is based on a principle discovered by Kraushaar, uses small diffraction gratings to produce and recombine separate beams of light. The usual two-parabolic-mirror schlieren system can be converted inexpensively to a diffraction-grating interferometer.

Experimental data are presented to verify the ability of the instrument to provide valid and reliable measurements of air density. From authors' summary

1711. **Collis, D. C., The dust problem in hot-wire anemometry,** *Aero. Quart.* **4,** part 1, 93–102, Aug. 1952.

The sensitivity and frequence response of hot wires are changed remarkably by the precipitation of minute dust particles on the upsteam surface of the wire during use. Miscroscopic examination of the wires showed dust deposits from 0.2 up to 10 microns in diam. Various means of cleaning the air in closed-circuit wind tunnels have been examined. Oiled wire screens and electrostatic precipitation eliminated only large particles, whereas the most efficient means was a 100μ wire grid. By further keeping the interchange of the air in the wind tunnel with that of the atmosphere to a minimum, the effect of dust on stability of hot-wire calibration can be diminished by at least 15 times.

W. Wuest, Germany

1712. **Mair, W. A., The sensitivity and range required in a Toepler schlieren apparatus for photography of high-speed air flow,** *Aero. Quart.* **4,** part 1, 19–50, Aug. 1952.

Author states: "A simple theoretical analysis is given of the quantities affecting the sensitivity and range of a schlieren apparatus. In regions of large density gradient, the deflections of the light rays may lie outside the normal working range. When this occurs, dark regions may appear in parts of the photograph that would normally be light. Examples of this effect are given, and it is shown that confusion can be avoided by taking photographs in pairs, with the knife edges or slits arranged to give sensitivities of opposite sign.

"The deflections of light rays in various typical disturbances in a supersonic air stream are calculated, using geometrical optics. Prandtl-Meyer expansions, boundary layers, and plane and curved shock waves are considered. From these calculated deflections it is shown that some of the anomalous effects commonly observed in schlieren photographs can be explained."

Throughout the analysis the assumptions are made that (1) ray deflections from perpendicularity to density gradient are small, (2) all rays in the refracting medium are arcs of circles, and (3) $\sin\theta \doteq \theta$. The reader will avoid confusion by remembering that nearly all the author's equalities involve these approximations.

An equation for curvature of a circular ray is given without stating the approximations involved. These are (1) of preceding paragraph, and the index of refraction of the medium is taken equal to one.

Author's expression for the deflection, at the second slit, of the image of the first slit incorrectly uses L, the total distance from the disturbance to the second slit. L should be replaced by the focal length of the second mirror. Deflections calculated using author's L will be too large by at least a factor of 2.

F. D. Bennett, USA

1713. **Holder, D. W., and North, R. J., Note on Mr. Mair's paper,** *Aero. Quart.* **4,** part 1, 51–53, Aug. 1952.

Suggestion of W. Mair (see preceding review) that duplicate schlieren pictures with opposite sensitivities should be taken in order to eliminate anomalies due to overloading of schlieren system is criticized as impractical. Procedures are given for insuring that a system will have sufficient range to avoid undesired overloading.

A schlieren system is described which utilizes a point source and a neutral density wedge instead of the usual second slit or knife edge. Better resolution and increased range are found with this system; the former because of minimization of diffraction effects, the latter because slits or knife edges are absent and the filter may be made as large as desired. Indications are given for use of this method in color schlieren work. F. D. Bennett, USA

1714. **Auriol, A., On a new method for the determination of aerodynamic characteristics of projectiles in wind tunnels** (in French), *C. R. Acad. Sci. Paris* **235,** 14, 701–702, Oct. 6, 1952.

The model of a projectile is launched with small velocity in a vertical supersonic wind tunnel. Due to the combined effect of the aerodynamic drag and of the earth's gravitational attraction, the velocity of the projectile decreases with time. The trajectory is photographically recorded. The aerodynamic coefficients of lift, drag, and moment are deduced, starting from the experimentally obtained time-space relationship.

A. Miele, USA

Thermodynamics

(See also Revs. 1508, 1700, 1735, 1751)

1715. **Ninci, M., Heat theory. Part 2: Thermodynamics** (in Spanish), *Rev. Fac. Cienc. exact. fis. nat. Univ. Cordoba* **13,** 1, 2, 3/4; 72–90, 441–495, 757–810; Jan./Mar., Apr./June, July/Dec. 1950.

1716. **Ninci, M., Heat theory. Part 3: Heat transfer** (in Spanish), *Rev. Fac. Cienc. exact. fis. nat. Univ. Cordoba* **15,** 1/2 47–113, Jan./June 1952.

1717. Beeton, A. B. P., Tabulated thermal data for hydrocarbon oxidation products at high temperatures, *Aero. Res. Counc. Lond. Rep. Mem.* 2542, 7 pp., Oct. 1946, published 1952.

Tables are given of the total heat and entropy of H_2O, CO_2, O_2, CO, H_2, OH, O and H for the range of temperature 1500–4000 K. Values are also given for the corresponding equilibrium constants over the same temperature range. The tables have been compiled with a view to their use in calculating the performance of liquid-fuel rockets. From author's summary

1718. Finck, J. L., Thermodynamics from a generalized standpoint, Brooklyn, N. Y., Flatbush Publ., 1951, xi + 124 pp. $4.

Author critically examines the foundations of classic thermodynamics and finds that certain assumptions have crept in more or less implicitly, which seriously restrict the progressive development of the subject. These assumptions are carefully considered, and it is shown how they may be removed. The author introduces the concept of a "complete" system, the behavior of which is extended to metastable as well as to the ordinary stable states. This makes it possible to study thermodynamics from a generalized standpoint.

The Kelvin-Planck and Clausius principles take a deeper meaning, whereas the entropy concept loses its significance. Author shows why and how systems acquire dissipative properties such as viscosity, and electric and thermal resistance, and why, in some cases, they vanish at absolute zero of temperature. The behavior of liquid helium at the λ-point is found to be entirely consistent with this theory.

From author's summary by H. D. Vasileff, USA

1719. Havemann, H. A., The cyclone combustion chamber and gas producer, *Mech. Engr., Bangalore, India* no. 2, 19–25, Dec. 1951.

A combustion chamber is described in which particles or drops of fuel assume a stable orbit in a vortex. The high relative fuel-air velocity gives good diffusion without turbulence. A number of arrangements are proposed but no quantitative data are given. It is claimed that very low-grade fuels can be utilized.

W. Squire, USA

1720. Ledinegg, M., Theory of firing circular burners (in German), *ZVDI* **94,** 28, 921–927, Oct. 1952.

Processes in vertical and oblique circular turbulent burners are discussed theoretically. The motion of the pulverized coal particles, serving as fuel, the duration of their sojourn in the air stream, their rate of combustion and of deposition on the walls are calculated. Approximate formulas are derived for the processes on the surface of the slag, and for losses due to unburnt particles.

From author's summary by W. Hitschfeld, Canada

1721. Blackshear, P. L., Jr., Driving standing waves by heat addition, *NACA TN* 2772, 46 pp., Aug. 1952.

The problem of combustion instability in rockets, ramjets, and other combustion equipment results in a need for an understanding of this phenomenon. A one-dimensional flow theory was derived to describe a mechanism whereby a flame drives or damps a standing wave, and experimental data were obtained to check the theory. The reflection, transmission, and amplification of waves passing through a flame were determined from the continuity and momentum equations. The waves were considered to pass through the flame with their velocity amplitude unaltered so long as the flame area remained unchanged. A change in flame area was considered to result in new waves propagating simultaneously into the hot and cold gases on either side of the flame.

The phase requirements for driving or damping are postulated, and these requirements vary depending on the value of the parameter $(1 - 2M_0)/[(T_1/T_2)^{1/2} + 2M_0]$, where M_0 is the Mach number for the flow approaching the flame, and T_1/T_2 is the temperature ratio (lower temperature/higher temperature) across the flame. When this parameter has a value greater than unity, the flame-generated wave passing into the hot gas dominates. When the parameter is less than unity, the flame-generated wave passing into the cold gas dominates. When the parameter has a value of unity, these waves are of equal magnitude, and the driving criterion is that proposed by Rayleigh; namely, that, for heat to drive a standing wave, the heat input should occur at a location where the pressure in the standing wave varies and the heat input should maximize at a time when the pressure is near its maximum value.

In the classical "singing tube" experiment of Rijke, $M_0 \cong 0$ and $T_1/T_2 \cong 1$, thereby giving $(1 - 2M_0)/[(T_1/T_2)^{1/2} + 2M_0] \cong 1$; Rayleigh's criterion was, therefore, adequate to explain these results. In the high-velocity combustion equipment used in jet-propelled aircraft, however, the value of the parameter may differ considerably from unity, and the Rayleigh criterion is not adequate for these conditions.

The experimental verification of the new theory consisted of measuring the ability of a flame to drive and to damp a standing wave. A homogeneous propane-air mixture was passed through a 1-in. diam burner tube, and the flame was seated on a small perforated disk, or "flame-holder." The standing waves were introduced into the tube by a piston speaker. Factors investigated included fuel-air ratio, inlet temperature, sound amplitude, inlet velocity, and flame-holder position.

The experimental results are in accord with the predictions of the theory. J. H. Childs, USA

1722. Moutet, A., Method for rapidly measuring and registering flame temperatures (in French), *Rech. aéro.* no. 28, 21–30, July/Aug. 1952.

An optical method of flame-temperature measurement in high-velocity gas streams is described. A ray of light from an incandescent lamp is focused across the gas stream and directed against the sensitive layer of an electronic multiplier tube preceded by a narrow band-width filter. The impulses corresponding to the radiation passing the filter are visualized by means of an oscilloscope. The method of computing the temperatures on the basis of the oscilloscope patterns is explained in detail, together with the necessary theoretical relations.

E. Haenni, Switzerland

1723. Dery, R. J., Development of a combustion wave in a flowing gas, Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 235–245, 1949. $13.50.

Author discusses kinematics of ignition and of developed flames in flowing gas. He presents a mathematical model for growth of flame in Poiseuille flow from small spherical ignition source, assuming that the gas undergoes no expansion across the flame front. Graphical solution of typical case is shown. Schlieren motion pictures of actual ignition bear resemblance to the graphical solution.

In an actual gas flame, expansion of gases across flame front is large. This requires that streamlines alter their course significantly on approaching the combustion zone so that a horizontal velocity component can be produced, due to pressure gradient across the zone. Equations relating refraction of stream tube to change of density for both plane and curving flame surfaces are given. Typical pressure drops across combustion zone are calculated.

Major part of author's work is presented more succinctly by B. Lewis and G. von Elbe [AMR 5, Rev. 2492].

Marjorie W. Evans, USA

1724. Bolte, W., The change of state of vapors in long pipings (in German), *Brennstoff-Wärme-Kraft* **4**, 9, 302–305, Sept. 1952.

Paper deals with the development of a numerical integration method to determine the change of state of vapors in long pipes. Both heat transfer and friction are considered to accompany the flow. The physical simplifications are: (1) The internal and external film coefficients are infinite; (2) the friction factor is constant over the length of the pipe. The numerical integration is based on an equation relating the rate of change of the entropy with respect to pressure to the specific volume, and to the temperature of the vapor. It is presupposed that the initial conditions, the pipe characteristics, and the flow rate are known. Changes in entropy are then computed for small increments of pressure, using the mean values of the temperature and the volume for the pressure increment as obtained from vapor tables. The locus of the entropy values is drawn on the Mollier chart, and thus it becomes possible to predict the vapor properties at the final condition.

The proposed method is a contribution to steam-line design and should yield results fairly close to the actual data.

A. B. Cambel, USA

1725. Yen, S. M., Korst, H. H., and McCloy, R. W., Gas dynamic investigation of a valveless pulse jet tube, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 507–520, 1952. $6.

Analysis is based on the method of characteristics. Engine configurations studied consist of two constant-area ducts, a larger one forming the combustion chamber and exhaust pipe, and a smaller one the inlet duct. Back-flow from the combustion chamber into inlet duct is treated as flow through a Borda nozzle. Various length and area ratios are considered, as well as operation with and without forward flight speed. Conclusions are reached with regard to the possibility of static operation and on the effects of engine configuration. Reviewer feels that, in view of the sweeping assumptions that are, unfortunately, necessary to make the problem amenable to analysis, results must be interpreted with great caution. For instance, preparing a characteristics diagram in such manner that the combustion-chamber pressure agrees with experimental data does not necessarily lead to the correct wave phenomena, since the latter are, in general, not uniquely related to the pressure history at one point of the duct.

G. Rudinger, USA

1726. Simon, F. E., Kurti, N., Allen, J. F., and Mendelssohn K., Low temperature physics. Four lectures, New York, Academic Press; London, Pergamon Press, 1952, vi + 132 pp. $3.50.

This short book by four leaders in the low-temperature field provides an excellent and most readable introduction to this rapidly developing branch of physics. Professor Simon leads off by giving a concise up-to-date survey of the whole field. He touches briefly on the thermodynamical and quantum-mechanical principles involved, and discusses the various methods now in use or projected for the attainment of low temperatures. He explains that the low-temperature behavior of such properties as specific heat, thermal conductivity, and the tensile strength have essential connection with the structure and purity of materials. Also, that experience with substances of extremely low boiling points (notably helium) may shed important information on the behavior of other substances at very high temperatures and extreme pressures. He sounds a general warning that low-temperature physics must not confine itself to temperatures in the helium range, as many important phenomena can only be understood properly if considerably higher temperatures are included in the discussion.

Dr. Kurti's article deals in more detail with methods of reaching temperatures below 1 K, chiefly the method of adiabatic demagnetization of paramagnetic materials, including a very interesting account of the latest efforts at adiabatically demagnetizing nuclear paramagnetics. A short section deals with the methods of measuring these low temperatures.

Professor Allen explains the special role played by helium. He gives the phase diagrams and a short account of the transport properties; also of the two-liquid theory suggested for the explanation of such strange phenomena as the λ-point, or the mobile film.

Dr. Mendelssohn, in the final essay, describes superconductivity and the theories that have been suggested for describing and explaining it.

Each of the contributions has detailed references to recent literature, as well as to books and articles of the past fifteen years. The book may not be a textbook of cryogenics, but it is a most readable, well-planned, and stimulating exposition which neophytes (with some background in physics) and old hands alike will enjoy.

W. Hitschfeld, Canada

Heat and Mass Transfer

(See also Revs. 1467, 1626, 1716, 1743, 1772, 1774, 1780)

1727. Ostroumov, G. A., A quantitative optical method of examining heat and diffusion phenomena in the case of the plane problem and the slightly deformed almost-plane surface (grid method) (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **71**, 5, 887–890, Apr. 1950.

In place of the customary knife edge in the schlieren optical system, a grid composed of equally spaced horizontal and vertical wires is used. In this way the photograph of the test section will be marked out by a pattern of lines, each one of which represents a constant value of either the x or y component of density gradient. Of course, a point source of illumination, not a line source, is required. Photographs are included which demonstrate the usefulness of the method.

R. E. Kronauer, USA

1728. Kapitsa, P. L., Heat conduction and diffusion in a fluid medium with a periodic flow. I (in Russian), *Zh. eksp. teor. Fiz.* **21**, 964–978, 1951.

Consideration is given to the increase in effective thermal conductivity in the mean heat flow in an oscillating fluid medium. The increment of relative increase, termed the coefficient of wave transfer, is investigated for flow in tubes, slits, and channels. For the case of laminar flow in a circular tube with assumed periodic parabolic distribution, the wave transfer coefficient is determined in terms of series involving Bessel functions and zeros of Bessel functions. For the other configurations, familiar solutions are obtained. The analysis does not appear to be significantly fundamental, but does present several ingenious devices to handle the problem.

N. A. Hall, USA

1729. Kamínin, L. I., The difference in uniqueness theorems for the heat conduction equation and for systems of difference-differential equations (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **82**, 1, 13–16, Jan. 1952.

A. N. Tihonov [*Mat. Sbornik* **42**, 199–215, 1935] showed that if $u(x, t)$ is a solution of the heat equation

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}, \quad t \geqq 0, \quad -\infty < x < \infty \qquad [*]$$

and if u satisfies the growth condition (for some positive constants c and t_0)

$$\max_{0 \leqq t \leqq 0} |u(x, t)| e^{-cx^2} \to 0, \quad \text{as } |x| \to \infty$$

then u is uniquely determined by its values $u(x, 0)$ on the x-axis. In the solution of the heat equation [*] by the method of finite differences in x, one is led to consider the infinite system of ordinary differential equations

$$\frac{du_n}{dt} = u_{n+1} - 2u_n + u_{n-1}, \quad n = \ldots, -2, -1, 0, 1, 2, \ldots \qquad [**]$$

The author shows, as a special case of a uniqueness theorem for a more general infinite system of ordinary differential equations

$$\frac{du_n}{dt} = f_n(t;\ u_{n-r}, \ldots, u_{n+r}), \quad n = \ldots, -2, -1, 0, 1, 2, \ldots$$

where r is a fixed positive integer, that for the nonuniqueness of the solution of [**] one requires less restrictions on the growth of $u(x, t)$ than for the nonuniqueness of the solution of [*].

Courtesy of Mathematical Reviews J. B. Diaz, USA

1730. Garnir, H. G., On the propagation of the wave emitted by a point in a perfectly reflecting angle or wedge and the analogous problem of heat conduction (in French), *Bull. Soc. roy. Sci. Liège* **21**, 8/9/10, 328–344, Aug./Sept./Oct. 1952.

Applying the inverse Laplace transform to formulas developed in an earlier article [title source, 1952, pp. 119–140, 207–231], author derives formulas for the propagation of waves and for diffusion for an instantaneous point source in an angle and in a wedge. Thus, in particular, there is found a new form for the solution of the classical diffraction problem which was first solved by Sommerfeld in 1901. The results are interpreted physically for the wave case in terms of the superposition of direct, reflected, and diffracted waves. Boundary conditions corresponding to reflection with sign change (Dirichlet problem) and without sign change (Neumann problem) are considered, while the mixed problem, being soluble by simple extension of the given methods, is not.

Paper is of interest for its presentation of a comparatively straightforward method of solution for this group of diffraction and diffusion problems. J. Lorell, USA

1731. Thiruvenkatachar, V. R., and Ramakrishna, B. S., A case of combined radial and axial heat flow in composite cylinders, *Quart. appl. Math.* **10**, 3, 255–262, Oct. 1952.

Paper considers temperature distribution in a composite cylinder made of two different materials, inner cylinder $0 \leqslant r \leqslant a$, and outer cylinders $a \leqslant r \leqslant b$ having thermal conductivity and diffusivity coefficients ϵ_1, k_1 and ϵ_2, k_2, respectively. Boundary conditions: Flat ends of cylinder are maintained at zero temperature with outer surface insulated and perfect thermal contact between cylinders at $r = a$. Initially, cylinder is at uniform temperature. Temperature distribution is found for any time greater than zero.

Solution is obtained by means of Laplace transform. Positions of poles in inverse Laplace transform are obtained by a graphical method, and solutions verified in their contour integral form.

Method of solution is straightforward but laborious, and resulting expressions for temperature distribution are in the form of double infinite series involving Bessels functions.

Reviewer feels paper is an interesting mathematical excursion with but little practical utility. Major defect is necessity of repeating calculations for any change in the physical parameters of cylinder. W. A. Wolfe, Canada

1732. Rabinowicz, E., and Shooter, K. V., The transfer of metal to plastics during sliding, *Proc. phys. Soc. Lond.* (*B*) **65**, part 9, 393B, 671–673, Sept. 1952.

Investigations have been carried out on the amount of metal transferred when a radioactive metal is slid over the surface of a plastic. It is found that, in every case, metal fragments are transferred to the plastic in amounts that are of the same order of magnitude for the various metals and plastics examined. The close similarity of the results with those obtained with sliding metals suggests that, by a process analogous to the welding that occurs between metal surfaces, strong local adhesion occurs when metal and plastic are pressed and slid together.

From authors' summary

1733. Gray, V. H., Simple graphical solution of heat transfer and evaporation from surface heated to prevent icing, *NACA TN* 2799, 19 pp., Oct. 1952.

Equations expressing the heat transfer and evaporation from wetted surface during ice prevention have been simplified and regrouped to permit solutions by simple graphical means. Working charts for quick and accurate anti-icing calculations are also included. From author's summary by S. I. Pai, USA

1734. Van der Held, E. F. M., Evaporation of a free water surface into a stream of air, *Ingenieur* **64**, 41, Ch. 89–Ch. 94, Oct. 10, 1952.

Author reviews derivation of usual form of psychrometer equation, pointing out its inadequacy in view of the existence of air film which prevents direct contact between fresh air and the humid surface. He then shows how the results of Hilpert, Kirschbaum, and Lewis allow the evaluation of the relationship between heat and mass transfer through such a film for various conditions of ventilation. In the light of this work, author derives an improved psychrometer equation which reduces approximately to the usual form when the ventilation is good and the temperature not too high. The formulas obtained are used to compute values of the psychrometer "constant" for a range of wet surface temperatures and various conditions of ventilation. Expressions are also obtained for the rate of evaporation, both from open surfaces and in closed canals. W. Hitschfeld, Canada

1735. Grew, K. E., and Ibbs, T. L., Thermal diffusion in gases, Cambridge at the Univ. Press, 1952, xi + 143 pp. $4.50.

One of the Cambridge Monographs on Physics, this little book gives a concise account of the recent data and theoretical developments of this branch of the kinetic theory of gases. The subject is of interest to physicists because of the information the thermal-diffusion data provides on the force fields around molecules, and to engineers because of the possibility of using thermal diffusion apparatus for purifying mixtures that are otherwise difficult if not impossible to separate.

After reviewing the qualitative aspects of the kinetic theory of gases as it applies to thermal diffusion, including the recent development of Hirschfelder, Bird, and Spotz [*J. chem. Phys.* **16**, 968, 1948; *Chem. Rev.* **44**, 205, 1949] based on the Lennard-Jones molecular model, Grew and Ibbs discuss experimental methods applicable to measurements of the thermal-diffusion coefficients for gaseous systems. These involve various physical methods of analysis that produce no disturbance of the diffusing components. Alternatively, the temperature rise accompanying interdiffusion of two gases can be determined (the Dufour effect) and the ther-

mal diffusion constant for the mixture computed. It may be surprising to some to learn that a transient difference in temperature as large as 7 C can be observed in a mixture of hydrogen and nitrogen that is being formed by interdiffusion of the pure components.

Although the concentration difference that can be produced in a binary gas mixture by application of a temperature gradient to a stationary mixture is only about 3 mole per cent in the most favorable case ($H_2 - N_2$) for a temperature difference of 100 C, nearly complete separations of isotopic mixtures, such as HCl^{35} and HCl^{37}, have been obtained in an apparatus employing natural convection circulation to obtain countercurrent contact between cold and hot (heavy and light) streams. Conditions of optimum operation of such equipment are discussed.

The book concludes with a short survey of thermal diffusion in liquids, sometimes called the Soret effect. Here a theoretical development is largely lacking. Data for aqueous salt solutions are numerous and show that a difference in molality of 0.3 can be produced in 2-molal sodium hydroxide, for example, by a temperature difference of only 14 C. The extremely slow rate of attainment of separation equilibrium, owing to the very low coefficients of ordinary diffusion in liquids, is the principal deterrent to practical application.

This is a very easily readable, modern, authoritative account of a difficult subject. It should be a part of the library of anyone interested in basic diffusion problems.

R. L. Pigford, USA

Acoustics

(See also Rev. 1663)

1736. Borgnis, F. E., Acoustic radiation pressure of plane-compressional waves at oblique incidence, *J. acoust. Soc. Amer.* 24, 5, 468–469, Sept. 1952.

The forces due to acoustic radiation in a beam of finite cross section in a nonviscous medium striking a plane reflector at oblique incidence are derived from simple mechanical considerations. The formulas are applied to a wedge-shaped vane. For a vane, the wings of which include an angle of 90°, the force turns out to be quite independent of the coefficient of reflection at the boundary between vane and medium.

From author's summary by Keeve M. Siegel, USA

1737. Moretti, G., Acoustic field of a line distribution of singularities in rectilinear nonuniform motion (in Spanish), *Comun. Inform. Esc. Sup. Aerotecn., Cordoba,* 12 pp., May 1952.

The acoustic plane field due to a singularity moving with rectilinear but not uniform velocity is studied, using the method of separation of variables and Fourier-integral expansion. Actually, the result is well known and the method could be simplified; however, it seems interesting to point out some details in order to clarify a method suitable for the problems in nonhomogeneous media. Also, the field form at different times is analyzed in the case of a uniformly accelerated motion; here it is possible to point out the growing of a supersonic zone and of a singular wave, due to the original singularity, when it exceeds the velocity of sound.

From author's summary

1738. Gershman, S. G., Correlation coefficient as criterion of the acoustical quality of a closed room (in Russian), *Zh. tekh. Fiz.* 21, 12, 1492–1496, Dec. 1951.

A comparison of the experimental values of R, the coefficient of correlation of the sound oscillations at two points in the sound field for different rooms, suggests to author that the acoustic quality of a closed room is represented more satisfactorily by the correlation coefficient than by the time of reverberation. R appears to be a function of the sound spectrum, the coefficient of absorption of the boundary surfaces, as well as the coordinates of the sound source and of the points of observation. In a room where the time of reverberation is small, the value of R is nearly equal to 1; in a room where the time of reverberation is large, the value of R is nearly equal to zero; and, in general, R has a value intermediate between these extremes. Nevertheless, R appears to be more sensitive to parameters other than the time of reverberation; e.g., it is characterized to a much greater extent by the sound process at different points. For a given room, a given spectral function of the sound source, and given positions of the, sound source and of the points of observation, the correlation coefficient appears to be a function only of the ratio of the intensity of the reflected sound to that of the direct sound. In this article, only a short account is given of some of the experimental results obtained in the Acoustic Laboratory of the P. V. Lebedev Physics Institute (Academy of Science, USSR), and the theory and description of the experiments are to be given later. Graphs are given which show the correspondence between the calculated and experimental results for a "white" source of sound used with octave filters for the ranges 800–1600 cps, 1600–3200 cps, 3200–6400 cps.

Marie Goyer, England

1739. Fehr, R. O., Wells, R. J., and Bray, T. L., Acoustic design of aircraft gas turbine test cells, *J. acoust. Soc. Amer.* 24, 5, 480–489, Sept. 1952.

The high noise level associated with aircraft gas-turbine operation creates two noise problems: (1) The reduction of the noise in the neighborhood of the installation to an acceptable level, and (2) the protection of operating personnel from excessive noise. This paper reports work done by the Aircraft Gas Turbine Division of the General Electric Company at their plants in Lockland, Ohio, and in Lynn, Mass. Permissible sound levels were established for surrounding residential areas. The attenuation due to spherical divergence, and also the probable deviation due to varying atmospheric conditions, were determined. Thus the sound level permissible at the exhaust stacks of the test cells was obtained. Knowing the noise level inside the test cell, the required sound attenuation of the stacks was calculated. Various acoustical treatments were investigated. An acoustical design is proposed which makes use of a combination on various duct treatments, and which meets the established design objectives. The permissible noise level inside the control room is discussed, and the required attenuation through the barrier between test cell and control room is calculated. A design for a control room meeting the established noise-level criterion is proposed.

From authors' summary

1740. Exner, Marie-Luise, Sound attenuation by rubber and steel springs (in German), *Acustica* 2, 5, 213–221, 1952.

The fundamental relations applicable to the vibration isolation of heavy machinery are reviewed. The simple moving system is idealized as a completely rigid and loss-free mass attached to a dissipative mechanical line which may be more than a wave length long, and which acts as a simple spring at low frequencies. Measurements made with both steel and rubber springs agreed satisfactorily with the idealized calculations. The rubber used had about ten times the damping factor of steel, thus increasing its isolation near resonance at the expense of the isolation afforded at high frequencies. With an improperly terminated two-section low-pass mechanical filter, the opposite action was observed.

V. Salmon, USA

1741. Schoch, A., and Fehér, K., The mechanism of sound transmission through single leaf partitions, investigated using small scale models, *Acustica* **2, 5, 189–204, 1952.**

Author first discusses theory of sound transmission through thin plates of finite area, and shows that, while an adequate qualitative theory can be obtained, quantitative theoretical results are not feasible. Accordingly, he has measured sound transmission of small scale models (representing single-leaf partitions) using plane waves at varying angles of incidence, and also diffuse (reverberant) sound. Results show Cremer's "coincidence effect," also the existence of additional transmitted waves due to boundary effects. Reviewer believes this work is an important advance in the understanding of sound transmissions mechanisms. P. H. Parkin, England

1742. Mellen, R. H., The thermal noise limit in the detection of underwater acoustic signals, *J. acoust. Soc. Amer.* **24, 5, 478–480, Sept. 1952.**

Author develops theoretical expression for thermally generated acoustic noise in the ocean; this noise is many orders of magnitude below that measured from 1 to 25 kc. At these frequencies, low hydrophone electroacoustic efficiencies will not decrease the electrical signal to noise ratio. Above 50 kc, where extrapolations indicate thermal noise will predominate, maximum efficiencies would be desired.

Reviewer feels that some of the mathematics is both unnecessary and wrong, and that the use of equivalent frequency-dependent temperatures (30,000 C at 10 kc) for measured noise is misleading. E. Ackerman, USA

1743. Ener, C., Gabrysh, A. F., and Hubbard, J. C., Ultrasonic velocity, dispersion, and absorption in dry, CO_2-free air, *J. acoust. Soc. Amer.* **24, 5, 474–477, Sept. 1952.**

The velocity, dispersion, and absorption of ultrasonic waves in dry, CO_2-free air have been measured at 32 C, and at two and three Mc/sec, and at pressures ranging from 0.020 to one atm. Dispersion of the velocity has been found beginning at 30 Mc/atm, increasing by 5 % at 100 Mc/atm, accompanied by a large increase in absorption such that, at the higher limits of f/p, reached measurements became nearly impossible with the equipment used. The ratio $\alpha_{exp}/\alpha_{class}$ decreased from about 2.4 to 1.3 and C_v/R from 2.5 to nearly 1.5 as f/p increased. The changes in velocity, absorption, and internal specific heat are interpreted as the result of the slowing of energy exchange between translational and rotational states. Assuming that relations for relaxation of translational-vibration exchange also hold for this case, the relaxation time for translational-rotational exchange as derived from the dispersion measurements has been found to be 2.29×10^{-9} sec. This corresponds to a frequency of the midpoint of the dispersion curve of 116 Mc/atm, and to 16 as the number per molecule of collisions required for an energy exchange between translational and rotational states. Absorption results were more difficult to secure; using low frequency values, a relaxation time of about 3×10^{-9} sec is indicated, giving 87 Mc/atm as the f/p value of the midpoint of the dispersion curve, and 21 as the number of collisions required for the energy exchange.

From authors' summary

1744. Bennett, G. S., A new method for the visualization and measurement of ultrasonic fields, *J. acoust. Soc. Amer.* **24, 5, 470–474, Sept. 1952.**

A new method for the observation of ultrasonic field distributions is described, utilizing a starch plate in a dilute solution of iodine in a manner analogous to the use of photographic emulsions. Near-field diffraction patterns are shown as illustrative of results, which appear to be superior to those of other methods, and the advantages of the new method over previous techniques are described. From author's summary

1745. Petralia, S., Ultrasonic interferometry in gases (III). Velocity and absorption of ultrasonics in sulphur dioxide (in Italian), *Nuovo Cim.* **9, 9, 818–824, Sept. 1952.**

The propagation velocity and the absorption of ultrasonic waves of different frequencies in sulphur dioxide have been measured. The molecular heat capacity C_i due to the internal vibrations of the molecules, the relaxation time τ of the vibration energy, and the probability P_{10} of nonexcitation of the vibration states are calculated. Author finds $C_i = 1.476$ cal/mole, $\tau = 1.85 \times 10^{-7}s$, and $P_{10} = 0.54 \times 10^{-3}$.

From author's summary

1746. Nedospasov, A. V., On the theory of sound produced by a rotating sphere (in Russian), *Zh. tekh. Fiz.* **22, 4, 579–584, Apr. 1952.**

The problem of determining the sound field of a rotating propeller is usually solved by linearization of the differential equations of the problem. Then the solution is valid only outside a certain cylindrical region enclosing the propeller. The present article raises the question how thick that region must be, and answers it for the simple example of a sphere with radius r, rotating around an axis on a distance R from its center.

The terms of the nonlinear differential equations are computed with the aid of the solution of the linearized problem. The (omitted) nonlinear terms are compared with the linear ones. For $R = 25r$, the former are 20–25% of the latter on the surface of the sphere, and only 3–4% at a distance $2r$ from its center. W. H. Muller, Holland

Ballistics, Detonics (Explosions)

(See also Revs. 1714, 1717)

1747. Gabeaud, A.-L.-M., Attempt at determination a priori of the efficiency of explosive projectiles against personnel in the open (in French), *Mém. Artill. fr.* **26, 3, 685–704, 1952.**

Author comments unfavorably on earlier work by the German, Capt. Justrow (1921), on the topic of this article. Author subdivides the theory into three phases; (1) fragmentation of the shell case, (2) exterior ballistics of the fragment, (3) lethal power of the fragment. After an elaborate theoretical study, author concludes that, using a single observation of a shell loaded with melinite, one obtains an explicit formula for the number N of fragments, serving for every projectile loaded with melinite. Author next examines the space distribution of fragments by weight, and offers an empirical law shown by graph. The exterior ballistics discussion starts with examination of the initial velocity of the fragments. The path in air and the lethal position of the path are found by theory. The probability of hitting and killing is next explored. A final over-all study of efficacy is rendered clear by a numerically worked-out example. Beyond determination of a few constants empirically, the work is based entirely on theory, but provides explicit numerical answers.

A. A. Bennett, USA

1748. Sundin, E., Valuation of anti-aircraft guns. Some results from calculations concerning different AA guns (in Swedish), *Artill. Tidskr.* **81, 1, 6; 21–27, 187–190; 1952.**

Author discusses in the first part some principal problems of AA-shooting and the value of some light AA-projectiles. Ap-

proximate formulas are given for the effect of a single shot and for the number of shots available against attacking aircraft of variable speed; later, formulas for range, time of flight, etc., are applicable for calculations and trackers.

In the last part, the author discusses the optimal caliber of light AA-artillery and compares their possibilities. He also gives some practical formulas for such a comparison.

R. Sjöberg, Sweden

1749. Palechek, E. M., Approximate integration of equations of exterior ballistics by the method of S. A. Kazakov with respect to vertical parameters (in Russian), *Prikl. Mat. Mekh.* **16**, 4, 505–510, July/Aug. 1952.

Kazakov's method [*Prikl. Mat. Mekh.* **9**, 129–138, 1945] is extended to the case where either the ordinate of the center of gravity of an artillery shell or the vertical component of the velocity of the center of gravity is taken as the independent variable [see AMR **4**, Rev. 3271]. E. Leimanis, Canada

1750. Touchard, L., On the anomalies in the quickness of tubular powders (in French), *Mém. Artill. fr.* **26**, 2, 297–334, 1952.

Results on rates of burning of tubular powders are given which are inconsistent with the chemical form function theories. As the length of the tube is increased, it is found that the rate of burning at first decreases, as expected, but then increases, in some cases passing through a maximum. The phenomenon is explained in terms of gas flow through the interior of the tubes, giving rise to erosion of the propellant. The theory is developed quantitatively and applied to the data.

K. J. Laidler, USA

1751. Dyrgalla, R., Practical development of rocket motor (in Spanish), *Cienc. y. Técn.* **119**, 602, 39–58, Aug. 1952.

A review is given of theoretical and empirical relationships involved in the design of rocket engines. A. Miele, USA

Soil Mechanics, Seepage

(See also Revs. 1568, 1611)

1752. Anonymous, Soil mechanics for road engineers, London, Her Majesty's Stationary Office, Road Res. Lab., 1952, xxiv + 541 pp. **30s.**

This excellent book, written by the staff of the soil mechanics section of Road Research Laboratory, England, is the first of three projected volumes to replace the book, "Soils, concrete and bituminous materials," 1945. Though written primarily for British engineers, it should be of interest to anyone, if only for its 130 plates and 235 figures. All current British and U.S. practices are stated and compared. Mathematical development of various theories are usually omitted, but adequate references are given. All experiments are described in detail, with description of equipments, step-by-step procedure, and sample tabulation of results.

Some chapter headings are: Nature of soils; Identification and classification tests; Chemical tests; Roadmaking aggregates; Chalk embankments and subgrades; Soil survey procedures; Compaction of soil; Road construction with soil and low-grade aggregates; Soil stabilization, mechanical, with cement, with bituminous materials, with resinous materials; Construction methods in soil stabilization; Soil moisture and the factors governing its movement; Subsoil drainage and moisture control, frost damage to road foundations; Measurement of soil strength; Pavement design; Foundation failures; Stresses and bearing capacity of ground; Consolidation of compressible soils; Settlement of embankments; Construction of roads on swampy ground; Stability of clay slopes; Equipment for soil-testing laboratory. M. Pei, USA

1753. Malíshev, M. V., On the question of stability of hydrotechnic constructions stressed in shear (in Russian), *Gidrotekh. Stroit.* no. 12, 35–38, Dec. 1951.

In connection with great hydrotechnic works on weak subsoils in the USSR, many studies have been devoted to stability of constructions, exposed to eccentric vertical forces as well as to horizontal shearing forces. Important is the question of the shape of a wedge underneath the footing and statically forming a part of the footing. In the laboratory VODGEO, extensive experiments showed that even with small eccentricities this wedge does not occupy the whole base of the footing. The form of the wedge was ascertained in a photographic way, the camera being fastened to a footing and moving along with it. A scheme of the equipment is pictured. V. Mencl, Czechoslovakia

1754. Tschebotarioff, G. P., Influence of "arching" on the distribution of lateral earth pressures (in German), *Bautechn.-Arch.* no. 8, 13 pp., 1952.

After a historical survey of the concept of "arching" in the problems of earth pressure (Ehlers, 1910; Möller, 1922; Terzaghi, 1939; Ohde, 1938, 1948–50), author gives accurate definition of true arching, terming it as a stressed state to be treated with the theory of arches, i.e., each layer of soil carries its own weight. He points out further that, in the theory of earth pressure using slip lines and slip surfaces, the fact that shearing resistance is not arrived at simultaneously in every part of slip line has been overlooked so far. This is the case, however, especially when one part of an earth mass expands and becomes looser.

The attempt is then made to determine the value of earth pressure, using the theory of arches, and author gives the formula of stress distribution, which is uniform on the back of the wall, the resulting force being greater than that furnished by the silo theory, especially on the upper part of the wall; the Coulomb value can be greater or smaller, according to the relative breadth of the arching soil layer.

Finally, author examines, based on Mecke's and his own experiments [AMR **5**, Revs. 281 and 2514], the conditions of true arching, and states that arching occurs only in the case of rigid supporting parts of wall, when the soil beneath the arch carries out a well-determined movement, and only in connection with cohesionless material, never in clayey soils.

Á. Kézdi, Hungary

1755. Robins, J. S., Some thermodynamic properties of soil moisture, *Soil Sci.* **74**, 2, 127–139, Aug. 1952.

Paper discusses the evaluation of the specific free energy by the static vapor pressure methods and the specific heat content from heat of wetting measurements. From these two properties, specific entropy is computed on the basis of which property the author conjectures as to the mechanism of soil-moisture retention and the physical state of soil water. Three soils of the Yolo series with a wide textural range were used to present a diversity of moisture characteristics. In order to study both the wetting and drying curves of the hysteresis, two samples of each soil were used in each experiment. One sample was brought to a moisture content approximating the moisture equivalent, and the second sample was dried. The temperature and moisture ranges covered in the experiments were approximately 10 to 30 C, and 1 to 12%, respectively.

Both the calculated and experimental data are presented, where the presence of a hysteresis is clearly seen in spite of the reasonably

long time allowed to reach equilibrium in the experiments (76 to 95 days).

Each of the three properties studied was found to decrease with decreasing moisture content. The free energy was found to increase with increasing temperature, but the change was neither large nor consistent. The heat content and entropy were found to decrease with increasing temperature. The negative entropy values show that the randomness of the soil moisture is reduced over the range of moisture contents studied. This behavior leads author to believe that the major contributor to soil moisture retention for moisture contents, at least up to the permanent wilting percentage, is the electric force fields surrounding the soil particles. Y. S. Touloukian, USA

1756. Hank, R. J., Triaxial testing adapted to soils, flexible base, and foundations, "Triaxial testing soils bitum. mixtures," *ASTM Spec. tech. Publ.* no. 106, 138–151, 1951. $3.50.

Soil triaxial-testing methods were developed to simulate as closely as possible actual conditions of use. Materials for tests included disturbed, remolded soils or flexible base with or without aggregate (2 in. maximum size), and undisturbed cores of foundation material. Equipment and procedure are described in some detail for compacting specimens, making capillary wetting tests, and utilizing metal axial pressure cells in triaxial tests to meet requirements of economy, simplicity, convenience, and adequate specimen size (usually 6-in. diam and 8-in. height). Application of test data to design of flexible bases and analysis of foundation problems are illustrated and discussed. Presentation of flexible base results is somewhat like that for CBR and Hveem methods and has provided useful engineering information where employed. Foundation footing analysis involves several gross approximations but appears to be a promising method for realizing considerable savings by the elimination of excessive safety factors. G. J. Tauxe, USA

1757. Hudson, H. E., and Roberts, R. E., Transition from laminar to turbulent flow through granular media, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 105–117, 1952. $6.

Paper deals with factors governing flow of water and oil through porous and stratified media, with particular reference to the transition region. The paper forms, and is welcomed as, a critical study of the present status of the problem. Authors rightly stress the importance of standardized methods to be used in experimental work, so as to obtain comparable data; e.g., regarding the effect of particle shape and equivalent pore diameter. In experimental work with small specimens, it might be necessary to consider entrance and exit losses. P. W. Werner, Sweden

Micromeritics

1758. von Schelling, H., Most frequent particle paths on the unit sphere, *Trans. Amer. geophys. Un.* **33,** 4, 570–572, Aug. 1952.

In a previous note [AMR **5,** Rev. 15], author considered a particle moving at random in a plane. In this article, the model of plane random motions is transferred to the surface of a sphere. It is shown that the equations describing the most frequent paths may be expressed in terms of elliptic integrals of the first and third kind. Particular paths which pass through the poles are expressed by elliptic functions. L. A. Pipes, USA

1759. McNown, J. S., and Lin, P.-N., Sediment concentration and fall velocity, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 401–411, 1952. $6.

Concentration effects on the fall velocity of uniform particles in a homogeneous suspension were studied both analytically and experimentally. Oseen's linearized equations for the motion of a sphere in a viscous fluid were used as the basis of the analysis, which made possible the evaluation of the inertia effect.

The fall velocity for a homogeneous suspension of uniform particles was found to be a function of the concentration and of the Reynolds number. The theory was verified by experiments for concentrations up to 6% by immersed weight and for particle Reynolds numbers of approximately unity. The results indicate that, even for very small concentrations, the fall velocity is significantly reduced. (For a 0.1-mm sand at a concentration of 30 grams per liter, the decrease in fall velocity is as much as 20%.)

Reviewer believes that the consequence of this finding is far-reaching, and its applicability should not be limited to the field of sediment analysis. Extension of the theory to larger particle sizes and to sediment mixtures is urgently needed. H. A. Einstein, USA

Geophysics, Meteorology, Oceanography

(See also Rev. 1511)

1760. Toropova, T. P., Determination of the amount of water vapor contained in the atmosphere, by spectroscopic method (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **86,** 1, 59–61, Sept. 1952.

Absorption of sunlight in the spectrum between $\lambda = 0.94\mu$ and 1.01μ, caused by vapor in the air, is used for estimating the content of moisture in the whole atmosphere. Observations were performed during the summer of 1951 in Central Asia, at elevation of 1400 m over the sea level. Reduction factors to transfer the spectrometric data into water content were determined in the geophysical observatory Alma-Ata. The total amount of moisture in the atmosphere was determined as 0.3 to 2.2 cm of water. S. Kolupaila, USA

1761. Malkus, Joanne S., The slopes of cumulus clouds in relation to external wind shear, *Quart. J. roy. meteor. Soc.* **78,** 338, 530–542, Oct. 1952.

Meteorologists, and forecasters in particular, have too long ignored the problem of cumulus formation. This paper is, therefore, valuable if only because it contains observational evidence of cumulus behavior and raises many pertinent issues. Three series of photographs at 30- or 6-sec intervals show towers developing in different horizontal wind profiles. The theory assumes that clouds experience drag because they mix some surrounding air into themselves and also form drag. The mixing process, called "entrainment," is believed to take place because of the low liquid-water content said to be measured in cumulus, and because towers do not usually reach the height predicted by the parcel method; but no claim is made that the mechanism is understood. The form drag has been taken as equal to that of a circular cylinder, and the slope of a cloud tower ascending through shear is computed. The model is undoubtedly crude but leads to answers of the right order of magnitude. In particular, it gives the order of relative horizontal velocity of a cloud. The conclusion that the slope remains constant is thought to be in error because the updraft is not constant in actual clouds, though the pictures suggest to the reader that the geometry of the model is as erroneous as its kinematics. Wind shear is shown to reduce the height reached by cumulus towers.

The mathematics is somewhat elaborate for the purpose; many of the assumptions are questionable, but this is only to be expected in the first paper on the subject. R. S. Scorer, England

1762. **Sheppard, P. A., and Omar, M. H., The wind stress over the ocean from observations in the Trades,** *Quart. J. roy. meteor. Soc.* **78,** 338, 583–589, Oct. 1952.

In spite of the great importance of the surface wind stress τ_0 over the oceans for understanding the workings of the atmosphere, its value is still quite uncertain. A computational approach is possible in the trades where the winds reach a maximum value at some distance h above the surface. Integration of the equation of motion under these conditions gives $\tau_0 = -l\rho\int^h \rho(v_g - v)dz$, since τ vanishes at h. In the formula, l is the Coriolis parameter, ρ the density, z the vertical coordinate, and v and v_g the actual and geostrophic wind components normal to the surface flow.

Statistical evaluation is made from three Pacific atolls and Puerto Rico. Although the data for evaluating v_g are admittedly weak, the results are most interesting; v_g is large and nearly constant through the layer. The contribution of v is small, as the turning of wind with height is much less than formerly thought. If the surface drag coefficient is computed from the surface stress, it turns out that the coefficient is independent of wind speed at the Pacific atolls. Its value is very low, about 1.0×10^{-3}, when compared to earlier work. Authors suggest that the coefficient may be proportional to the sea-air temperature difference. They also find much higher values over Puerto Rico, a mountainous island.

Although the computations are still in the beginning stage, the attack chosen by the authors must be regarded as fundamental to meteorological advance. H. Riehl, USA

1763. **Arakawa, H., Kinematics of meandering and blocking action of the westerlies,** *Pap. Meteor. Geophys., Tokyo,* **3,** 1, 12–18, Mar. 1952.

Using the velocity profile with maximum zonal wind at about 26.5° latitude, and assuming the conservation of the absolute vorticity, author derives the stream function for the finite perturbation motion. From author's summary

1764. **Schaffhauser, E., and Schaffhauser, J., The origin and propagation of atmospheric disturbances (air seismic)** (in German), *Helv. Phys. Acta* **25,** 5, 480–485, Sept. 1952.

This is a preliminary report on the origin and propagation of the air seismic; a fuller account will appear in the near future. The atmospheric disturbances observed in Switzerland always come from the quarter between NW and W, though the quarter of origin for each day shows rather large dispersion. It may be concluded that the air seismics, at least a part of them, are generated in a cyclone or near a cyclonic area.

Some measured phase velocities are larger than the sound velocity and others are smaller. For the description of the propagation of the barometric waves, two theories of sound waves and gravitational waves may be applied. Several discussions are given from the two points of view. A solution of the gravitational waves in the atmosphere gives a critical period (the minimum period of atmospheric disturbances) of $30 \sim 60$ sec, assuming proper stratification of air temperature in the troposphere. The solution of the sound waves in the atmosphere also gives other critical period (the maximum period).

H. Arakawa, Japan

1765. **Wippermann, F., The configuration of the average high-altitude wind fields and their causes** (in German), *Tellus* **4,** 2, 112–117, May 1952.

Paper is concerned with obtaining a qualitative estimate of the relative importance of orographic barriers, surface heat exchange, and surface friction in establishment of quasi-stationary perturbations in the upper-air westerlies. Such perturbations result in formation of semipermanent high- and low-pressure centers above certain geographical regions.

Using an asymptotic form of the vorticity equation and integrating, author obtains an expression for the equivalent barotropic change, averaged over a pressure interval, of the absolute vorticity component about the perpendicular to the isobaric surface.

Through modifications of this equation and with certain quantitative assumptions, author calculates relative contributions to the vorticity by the three afore-mentioned processes. Results indicate that contributions of the three are approximately equal. W. W. Berning, USA

1766. **Larras, J., Experimental research on breaking of waves** (in French), *Ann. Ponts Chauss.* **122,** 5, 525–542, Sept./Oct. 1952.

Breaking waves were investigated in the laboratory with measurements made of breaker heights, depths at breaking, and the velocity field within the breakers. The scope of the investigation covered beach slopes ranging from 1% to 27% with different beach bottom roughness, and for a range of incident periodic wave trains at each slope and roughness.

Author concludes breaking occurs at smaller depths on a rough beach than on a smooth beach with the same incident wave train, and the velocity distribution on the surface is related to that predicted from solitary wave theory, while beneath the surface the velocity distribution is related to that of progressive swells with the reference depth taken as the mean water level of the progressive system.

Reviewer believes scale effects due to the absolute size of the waves may be obscured in the summaries of the dimensionless presentation of breaker heights and depths at breaking. The majority of results are presented as tabular averages of a number of individual results, with no tabulation of individual results or deviations from the average. H. W. Iversen, USA

1767. **Laurent, J., and Devimeux, W., Experimental study of the reflection of a swell on shore obstacles** (in French), *Rev. gén. Hyd.* **18,** 65, 235–246, Sept./Oct. 1951.

Considerable damage due to wave turbulence and surf within marine enclosures in harbors is most often produced by reflection of swells from wall structures. Reflecting power of obstructions, as dependent on their profiles, is, therefore, to be studied, as has been done in the French Central Hydraulic Laboratory. Also, results obtained by the Spanish engineer Irribaren, by Schoemaker and Thijsse in the laboratory at Delft, and in the authoritative study by Mische are tested. The latter emphasizes the importance of both the parameter of curvature and the shape of a breakwater. In the recent French experiments by Larras, a complex generator for regular uniform waves was employed.

High reflecting power produces surges which exceed considerably the amplitude of the original swell. This, with possible resonance within an enclosure, produces disturbances greater than the original wave excitations. The concern, therefore, is to absorb as much, and to reflect as little impact energy as possible. A sloping bank is an excellent absorber, causing wave forms to disintegrate. The difficulty of docking ships is overcome by using docks mounted on battlements or built on piling. The marine engineer's compromise is often the combination of a vertical wall with an inclined section.

Starting with classical considerations, absorption should occur, theoretically, when the height of obstruction equals the amplitude (half the crest-to-trough), that is, when the wave hollow contacts the bottom. The slope of the bank, therefore, is mathematically dependent on the reciprocal of the period and on the square root

of the amplitude. However, the practical depths are usually greater than in this case; yet there is some experimental verification of this result (as shown in tabulation). The mean of slope for absorption, and slope for reflection, is shown to come within about 3% of the theoretical slope.

Three types of sea walls were tested in tank waves—a vertical wall with flat top, a vertical wall surmounted by a sloping wall at 30° to the horizontal, and a vertical wall surmounted by a slope of 45°. Various depths of submergence and of above-sea-level clearance were tried. Reflecting power was measured as amplitude of reflected wave divided by amplitude of incident wave. At antinodes of standing wave surges, the amplitude (half crest-to-trough) equals the numerical sum of the amplitudes of initial wave and reflected wave; and at nodes, the difference. The reflecting power is the difference divided by the sum.

For the vertical wall, tests naturally showed reflecting power to be less for submerged walls than for walls rising to sea level. Walls with top surface flush with the sea level, or with an angled-top rising from sea-level height, appear to have greater reflecting power than ones more submerged. In general, the reflecting power increases when the curvature of an incident wave is diminished (although the scattering of the tabulated data would appear inconclusive). The problem of reflection from various shapes is one of great complexity. E. Smith, USA

1768. Roseau, M., On the undulations of the sea on a shore (in French), *C. R. Acad. Sci. Paris* **232,** 6, 479–481, Feb. 1951.

Author calculates the potential $\Phi = e^{i(kz+\sigma t)}\varphi\ (x, y)$ which represents the irrotational motions of the sea on the shore. Two independent solutions are obtained on the condition that $|k| < \sigma^2/g$. The one is regular at the origin; the other has a logarithmic singularity at this point. From author's summary

1769. Tucker, M. J., A wave-recorder for use in ships, *Nature* **170,** 4329, 657–659, Oct. 18, 1952.

This instrument, developed by the (British) National Institute of Oceanography, is wholly contained within the ship's hull and, in this respect, is superior to previous devices which are reviewed. This method combines hydrostatic pressure against the hull measured about 10 ft below waterline, with doubly integrated accelerations of the hull measured at the same point. In the example shown, the latter part, i.e., ship motion, predominates strongly. Accuracy is estimated at ±10%.

P. Rudnick, USA

1770. Gerhardt, J. R., Crain, C. M., and Smith, H. W., Fluctuations of atmospheric temperature as a measure of the scale and intensity of turbulence near the earth's surface, *J. Meteor.* **9,** 5, 299–310, Oct. 1952.

Report of a few thermistor measurements of time and space autocorrelations of temperature fluctuations within 15 feet of the ground. The orders of magitude obtained appear plausible, but in view of inadequate instrument response and evident confusion on principles of turbulent flow, reviewer suggests awaiting better specified data. S. Corrsin, USA

1771. Fjørtoft, R., On a numerical method of integrating the barotropic vorticity equation, *Tellus* **4,** 3, 179–194, Aug. 1952.

A method is given by means of which quasi-permanent "velocity" fields may be constructed in which absolute vorticity is conserved if the atmosphere is treated as barotropic. For vorticity displacements, these fields may be considered as constant for time intervals of the order of magnitude of 24 hr. Some simple approximate integration formulas are given for the Poisson and Helmholz equations. A graphical procedure is introduced to derive the isoclines of vorticity and to perform the integration work.

From author's summary by H. Merbt, Sweden

1772. Davies, D. R., and Walters, T. S., Further experiments on evaporation from small, saturated, plane areas into a turbulent boundary layer, *Proc. phys. Soc. Lond.* (*B*) 65, part 8, 392B, 640–645, Aug. 1952.

Paper describes an experimental investigation designed to evaluate the effect of width and length on rates of evaporation from small, saturated, plane rectangular areas placed in turbulent flow. Higher rates of evaporation near the edges of the area, as predicted by authors, were observed. When the total rates of evaporation obtained were compared with the calculation of O. G. Sutton ["Atmospheric diffusion," London, Methuen, 1949] and that of the present authors [AMR **5,** Rev. 1587], it was found that Sutton's calculation for an infinitely wide area with a leading edge gives fairly accurate results, whereas the authors' previous calculation based on finite width and infinite length of the evaporation area gives considerably lower values than those obtained experimentally. However, as authors mention, it is interesting to note that the experimental value for the local rate of evaporation at a location far from the leading edge is only 4% more than the value given by their previous calculation. Thus, for a long and narrow area of evaporation their calculation may be expected to give satisfactory results.

Authors conclude also: "Finally, the results given in this paper provide further evidence to show that the approach to practical problems of turbulent diffusion and evaporation, initiated by Sutton (1949) using the concept of eddy diffusivity, is a powerful one, but in order to account theoretically for the effect on rate of evaporation of variations in length and width of area a full analytic, computable solution is needed to cover the effects of leading, trailing and longitudinal edges." C.-S. Yih, USA

1773. Dessauer, F., Mercier, A., Schaffhauser, E., and **Schaffhauser, J., Effect of quick gravity changes on the atmosphere** (in German), *Helv. Phys. Acta* **25,** 5, 476–477, Sept. 1952.

Formula derived by authors in a quoted paper gives effect of change of absolute amount of gravity. Changes in gravity direction are not considered. Sinusoidal variations have phase shift if period is below 300 sec approx. The amplitude of the effect is found to be too small to account for the observed small oscillations of the windless atmosphere, except possibly for those of very long periods; also, for the explanation of the latter, the effect is found to be probably too small. E. W. Beth, USA

1774. Rouse, H., Yih, C.-S., and Humphreys, H. W., Gravitational convection from a boundary source, *Tellus* **4,** 3, 201–210, Aug. 1952.

Free convection from line and point sources of heat is investigated in an approximate analysis based on the hypothesis of dynamic similarity of the motion at all elevations. Qualitative conclusions describing the vertical variations of the mass, momentum, and kinetic energy transport are supported by experiments which also provide empirical constants to enhance their usefulness in engineering applications. However, reviewer believes that the suggested extension of these conclusions to heat sources of finite width is unjustified, for in turbulent convection between horizontal surface and in atmospheric convection, the dimensions of the source are usually large compared to the vertical extent of the motion; the individual updrafts are time-dependent; and return currents play a significant role in modifying the transport mechanisms near the boundary. W. V. R. Malkus, USA

1775. **Bullen, K. E., and Burke-Gaffney, T. N., Detection of *S* waves in the earth's inner core,** *Nature* **170,** 4324, p. 455, Sept. 13, 1952.

This short note reports on an unsuccessful attempt to find evidence of shear waves through the earth's inner core. Such waves would be most easily observed at epicentral distances between 130° and 142° and between 145° and 155°. The number of earthquakes for which the amplitude of the anticipated wave would be large in these ranges is small. J. T. Wilson, USA

1776. **Wilson, R. M., and Burgess, L. R., A highly stable cathode-coupled amplifier for seismic recording,** *Bull. seism. Soc. Amer.* 42, 4, 341–347, Oct. 1952.

1777. **Lake, H., A comparison of the power law and a generalized logarithmic formula in micrometeorology,** *Trans. Amer. geophys. Un.* **33,** 5, 661–668, Oct. 1952.

It is shown in quite formal ways that the variation of wind speed with height, as given by E. L. Deacon's form for the power law [*Quart. J. roy. meteor. Soc.* **75,** 89–103, Jan. 1949], is similar to that expressed by H. Lettau's generalized logarithmic law [*Geophys. Res. Pap.* no. 1, AF Cambridge Research Center, Cambridge, Mass., 1949]. The height dependency as well as stability dependency of the exponent in the power formulation may be evaluated by an extension of the theory of turbulence in the atmospheric surface layer. Two geometrical parameters, i.e., the zero-level displacement and the roughness parameter, are obtained independently by the thermal stratification. In order to permit comparison between the predicted relation and actual observations, F. Pasquill's data [*Proc. roy. Soc. Lond.* (*A*) **198,** p. 116, July 1949] were used to plot values of the exponent for the layer against the corresponding observed Richardson number, which is a unique function of the stability parameter. The numerical comparison forecasts the observational results fairly well.

H. Arakawa, Japan

Lubrication; Bearings; Wear

(See also Rev. 1732)

1778. **Mansion, H. D., Some factors affecting gear scuffing,** *J. Inst. Petrol.* **38,** 344, 633–645, Aug. 1952.

The tested gear was driven by another similar gear with pressure loads rising from about 10 to about 70 lb, usually at a speed of about 2000 rpm. The load at the beginning of scuffing (in 5 min) measures the quality of the lubricant. Main results: Scuffing load rises with rising kinematic viscosity of the lubricant at a given temperature; the influence of the temperature is small in the range of 40 to 110 C; suitable additions to the lubricant may increase the scuffing load by a factor of up to 3.

E. I. Shobert, II, USA

1779. **Rabinowicz, E., Metal transfer during static loading and impact,** *Proc. phys. Soc. Lond.* (*B*) **65,** part 8, 392B, 630–640, Aug. 1952.

Experiments are described which investigate the metal transfer taking place when a radioactive hemispherically ended slider is pressed normally into a flat surface of the same or another metal. It is found that, under very varied conditions, metal fragments are transferred from one surface to the other, and this shows in a direct way that strong junctions are formed between metal surfaces in contact. The amount of metal transferred is small. In a typical case (copper on steel, clean, with load of 4 kg), the pickup is 2×10^{-11} g, corresponding to a uniform layer of thickness 0.1 Å over the area of the indentation. Experiments in which the load is varied suggest that, at higher loads, the oxide layer on the metal surfaces is broken up to a larger extent than at lower loads, and a more than proportional increase in metallic interaction and transfer takes place. An analogous effect is observed in the presence of boundary lubricants.

When the surfaces are impacted together, very similar results are obtained. Somewhat less pickup is observed than for static loading, and the difference is probably due to the fact that it takes time for strong junctions to be formed. Impact experiments with surfaces covered by lubricants show that a lubricant layer may be trapped between the surfaces, and this produces a large reduction in pickup without greatly reducing the amount of plastic deformation. W. Kochanowsky, Germany

1780. **Feng, I.-M., Metal transfer and wear,** *J. appl. Phys.* **23,** 9, 1011–1019, Sept. 1952.

The interface between each pair of opposed high spots of two solid surfaces pressed together is shown to be roughened to the form of a saw-tooth profile by the plastic deformation that occurs. This new experimental finding is the basis of author's hypothesis that the perfect matching and the consequent mechanical interlocking so achieved at the interface are the primary cause of the shear component of friction and of the two types of wear characterized by metal transfer and by the formation of loose wear particles, respectively.

In contrast to Bowden and others, author considers welding as the consequence and not as the cause of friction. More precisely, the shearing induced by sliding is supposed to take place not at the interface but, because of strain-hardening, at a section at some distance from and more or less parallel to the interface. A temperature flash is thought to be induced at the interface by the heat of shearing, and thus the sheared-off peak may become welded to its opposed high spot, provided that diffusion at the interface is rapid enough and the consequent adhesion is strong enough. In cases where this condition is not fulfilled, the sheared-off peaks would form loose wear particles.

Author claims that his hypothesis solves several explanatory difficulties inherent in the older, the welding hypothesis. One such difficulty lies in explaining the formation of loose wear particles and the preponderance, in certain cases, of this kind of wear as compared with metal transfer. Another such difficulty relates to the high order of magnitude (100 and more) of the coefficient of friction between two clean metal surfaces. Reviewer finds the new hypothesis exceedingly thought-provoking, but feels that its correctness can be judged fully only after the additional evidence announced by the author has been published.

H. Blok, Holland

1781. **Charnes, A., Osterle, F., and Saibel, E., On the energy equation for fluid-film lubrication,** *Proc. roy. Soc. Lond.* (*A*) **214,** 1116, 133–136, Aug. 1952.

To resolve the discrepancy existing in literature because two obviously different energy equations have been used, authors develop the energy equation by equating the work done on an element of fluid by frictional force exerted by moving surface, and pressure forces exerted by surrounding fluid, to the increase in internal energy of the element. Then, the energy equation agrees exactly with the one developed by Cope from the "dissipation function," by rederiving the reviewer's work expression [Vogelpohl, G., *ZAMM* **15,** p. 378, 1935; Cope, W. F., *Proc. roy. Soc. Lond.* (*A*) **197,** p. 201, 1949]. On the other side, the form of equation used by Christopherson [*Proc. Instn. mech. Engrs.* **146,** 126, 1941] and Cameron and Wood [*Proc. 6th int. Congr. appl. Mech.*, 1946] is in error, since it neglects the work done by pressure forces, the so-called "flow work" of thermodynamics. Pos-

sible reason for the confusion may be due to the fact that in large (i.e., over the entire film) area, the net contribution of the neglected terms is zero, a fact which the reviewer also has shown and generally proved by use of the Gaussian theorem [Vogelpohl, G., *VDI-Forschungsheft* no. 386, 1937]. Authors give a qualitative estimate of the error introduced by use of the incorrect equation.

G. Vogelpohl, Germany

1782. Barwell, F. T., The effect of lubrication and nature of superficial layer after prolonged periods of running, Symp. Proper. metall. Surf., Institute of Metals, London, 101–122, Nov. 1952.

General review of current concepts of lubrication and wear of metallic surfaces. Mechanisms of continuous wear, scuffing, pitting, abrasion, and fretting are discussed. Bearing-surface modifications such as scuffing due to local high temperatures, plastic flow of surface crystals, and Beilby layer formation are described. Metallographic changes underneath the surfaces of ball bearings subjected to Hertzian-type stress distributions during rolling action are discussed. Photomicrographs are shown of sectioned steel balls having such metallographic changes, and of balls with incipient cracks and pits generated during test runs.

Surface coatings of various types such as oxide layers, phosphated and anodized surfaces, metallic soaps, inorganic salt extreme-pressure lubricants, and polymerized organic and silicone lacquers are described. Methods of formation, frictional and load-carrying characteristics, physical properties, and theories of the lubricating mechanisms of these coatings are discussed.

T. P. Clark, USA

1783. Evans, L. S., and Tourret, R., The wear and pitting of bronze disks operated under simulated worm-gear conditions, *J. Inst. Petrol.* **38,** 344, 652–668, Aug. 1952.

Authors study wear and pitting occurring during rolling and sliding contact of peripherally loaded disks. Problem is applicable to worm-gear wear, as in automotive transmissions. Bronze disk with lands is operated against steel disk of smaller diameter. Wear is determined by measuring the decrease in depth of calibrated scratch. Pit formation, and surface and subsurface cracking are determined by photomicrography of cross sections.

Authors suggest that wear is caused by surface becoming hardened and brittle so that small particles become detached. Pitting is initiated by either surface or internal cracks, or both. Mechanisms of formation of surface and internal cracks are discussed, and crack propagation by hydraulic forces in lubricant is postulated.

T. P. Clark, USA

1784. Dies, K., Journal bearings and their materials (in German), *Werkstatt u. Betrieb* **85,** 8, 337–344, Aug. 1952.

Paper is a comprehensive review of existing knowledge, and refers particularly to German practice in the selection of bearing materials.

F. T. Barwell, Scotland

Marine Engineering Problems

(See also Revs. 1534, 1644)

1785. Barkla, H. M., High-speed sailing, *Trans. Instn. nav. Arch. Lond.* **93,** 235–249, 1951.

Experiments such as those of the Stevens Institute have been carried out only on conventional yachts, and such theory of sailing as exists has been similarly restricted to a small range of variations. To handle the problem in a more general manner relating all the relevant variables, a graphical method of solution has been evolved. Containing implicitly the corrections to be made to the direction and strength of the wind in virtue of the vessel's own motion, it is particularly apposite to the consideration of high-speed sailing. In this paper it has been applied to the speed range above $V/L^{1/2} = 2$, and the results are remarkable. The sail area necessary to give speeds of the order of 30–40 knots in winds of 20–30 knots is only about 400 sq ft per ton, but the required stability is far beyond the limits of a single hull. Such a combination may, however, be obtained by multiplying hulls and airfoils. The triscaph or three-hulled vessel described is believed to typify a class of vessel which might inaugurate a new era of sailing and terminate a half century of arrested development.

From author's summary by J. P. Breslin, USA

1786. Szebehely, V. G., Hydrodynamic approach to the slamming of ships, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 89–98, 1952. $6.

The slamming of a ship is assumed to be approximately similar to the dropping of a ship on a water surface. Considering only the unsteady hydrodynamic forces, the motions during dropping of parabolic and V-bottom ships are analyzed by using the classical added mass theory of Wagner. Dimensionless time histories of deceleration are obtained for V-bottom ships. Some agreement with theory is shown, but its significance is limited, since experimental and theoretical conditions were not directly comparable.

R. F. Smiley, USA

Biomechanics

1787. Cunningham, D. M., and Brown, G. W., Two devices for measuring the forces acting on the human body during walking, *Proc. Soc. exp. Stress Anal.* **9,** 2, 75–90, 1952.

Knowledge of forces acting on a body during walking is useful in calculation of muscular work, design of artificial limbs, and improvement of surgical techniques. Authors use two means to measure all forces acting; a loud measuring "pylon" substituted for the shank of a prothesis, and a force plate to measure floor reactions for normal or artificial foot. Both pylon (a hollow aluminum tube) and force plate are equipped with resistance strain gages which feed into electrical bridges. Static and dynamic characteristics of the equipment indicate that these direct-reading instruments measure dynamic loads accurately. One set of typical results is given.

E. Ackerman, USA

1788. Dal Borgo, V., Physical study of the normal and pathological aorta (in Italian), *Pontif. Acad. Sci. Scripta Varia* no. 10, 136 pp., 1952.

Author tabulates results of physical measurements made on a 3-mm ring taken from the descending tract of the thoracic aorta from each of 10 cadavers, including normal as well as pathological (arteriosclerotic). Among his conclusions (which also illustrate the nature of the measurements) are: In arteriosclerosis, the diameter and thickness are increased; Hooke's law is verified except in one sclerotic case; the modulus of elasticity varies from 0.1082 to 0.2696 kg/mm², with smallest values in the normals; rupture occurs on the range from 0.1628 (sclerotic) to 0.1240 (normal) kg/mm². Diagrams of deformation, and effects of hysteresis are presented and compared, but not easily described.

A. S. Householder, USA